Preoperative Checklist

Ohmeda Anesthesia Systems

1. Verify adequate pipeline supply and reserve cylinder supply.
2. Verify integrity of low pressure gas circuitry.
3. Verify proper functioning of electrical systems.
4. Verify proper functioning of gas flow control systems.
5. Verify integrity of patient breathing circuit.
6. Verify integrity and proper functioning of vaporizer(s).
7. Verify adequate vacuum source.
8. Verify integrity and proper functioning of gas scavenging interface valve.
9. Verify integrity and proper functioning of ventilator.
10. Verify integrity and proper functioning of monitoring system(s).

For detailed description of testing procedures refer to applicable Operation and Maintenance Manual or Technical Literature.

⚠ **WARNING:** User shall read all Operation and Maintenance manuals, all accompanying documents, and understand anesthesia system operation before use. Improper use of this anesthesia system can cause significant patient injury.

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Preoperative Checklist

Ohmeda 7810 Ventilator

1. Verify proper hose connection between bellows assembly and control unit.
2. Verify proper connection between bellows assembly and Patient Circuit.
3. Verify properly functioning scavenger system is connected to 19 mm port **(Exhaust)** on bellows assembly. Do not connect ventilator exhaust directly to the vacuum source.
4. Verify louvers on back of control unit are not occluded.
5. Verify proper connection of the pressure sensing tube, volume sensor, and O_2 sensor to the Patient Breathing System.
6. Verify operation and select the desired set points for user controlled alarms and the **Inspiratory Pressure Limit**.
7. Verify Tidal Volume, Rate, and Inspiratory Flow (I:E Ratio) controls are set to desired positions.
8. Verify **Inspiratory Pause** and **Mechanical Ventilation** switches are in desired position.

⚠**WARNING:** User shall read all Operation and Maintenance manuals, all accompanying documents and understand the operation of this ventilator before use. Improper use of this ventilator can cause significant patient injury.

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Preoperative Checklist

Ohmeda Tec 4/Tec 5 Vaporizers

1. Verify that the vaporizers are properly mounted, level and locked on manifold.
2. Verify that the vaporizer filler caps and/or keyed filler valves are closed and tightly sealed.
3. Verify proper agent level.

⚠**WARNING:** User shall read the Operators manual, all accompanying documents and understand the operation of this vaporizer before use. Improper use of this vaporizer can cause significant patient injury.

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Preoperative Checklist

Ohmeda GMS™ Absorber

1. Verify condensate has been drained and Drain Port/Sight Glass is completely closed.
2. Verify desired APL Setting with Selector Knob in Bag/APL position.
3. Verify Bag/APL - Ventilator Selector Knob is turned to desired position.
4. Verify integrity of Patient Breathing Circuit and all other connections.
5. Verify canister seal with lever in full Lock position and ensure adequate capacity of Soda Lime.
6. Verify proper assembly and functioning of Inhalation and Exhalation Check Valves.
7. Verify Oxygen Monitor Sensor is in place.

⚠**WARNING:** When Oxygen Monitor Sensor is not used, Sensor Port must be capped to help prevent loss of Patient Gas.

⚠**WARNING:** User shall read all Operation and Maintenance manuals, all accompanying documents, and understand the operation of this breathing system before use. Improper use of this breathing system can cause significant patient injury.

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Preoperative Checklist

Ohmeda 5210 CO_2 Monitor

1. Verify proper sample inlet tube connection and function.
2. Verify that the **System Master Switch** is turned to the **On** position.
3. Verify that the display indicates self-test when the CO_2 Monitor On-Off switch is switched to the **On** position.
4. Verify proper calibration of the N_2O and CO_2 display reading.
5. Verify that the CO_2 monitor is set to the desired high and low alarm limits.
6. Verify proper sample return tube connection and function.

⚠**WARNING:** User shall read all Operation and Maintenance manuals, all accompanying documents and understand the operation of this CO_2 monitor before use. Improper use of this CO_2 monitor can cause significant patient injury.

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Preoperative Checklist

Ohmeda 3710 Pulse Oximeter

1. Verify proper probe operation.
2. Verify proper probe connection from anesthesia system to patient.
3. Verify that the **System Master Switch** is turned to the **On** position.
4. Verify that the display indicates self-test when the Oximeter On-Off switch is switched to the **On Batt** position.
5. Verify that the Oximeter is set to the desired high and low alarm limits.
6. Verify that the Oximeter is set to the desired alarm volume and pulse volume.

⚠**WARNING:** User shall read all Operation and Maintenance manuals, all accompanying documents and understand the operation of this Pulse Oximeter before use. Improper use of this Pulse Oximeter can cause significant patient injury.

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Preoperative Checklist

Ohmeda 2120
Noninvasive Blood Pressure Monitor

1. Verify proper hose connections from anesthesia system to patient cuff.
2. Verify that the monitor executes self-test when **System Master Switch** is turned to the **I (On)** position. Display should indicate all 8's for several seconds after power is applied.
3. Verify that the monitor is set to the desired high and low alarm limits.
4. Verify that the monitor is set to the desired interval time.

⚠**WARNING:** User shall read all Operation and Maintenance manuals, all accompanying documents and understand the operation of this blood pressure monitor before use. Improper use of this blood pressure monitor can cause significant patient injury.

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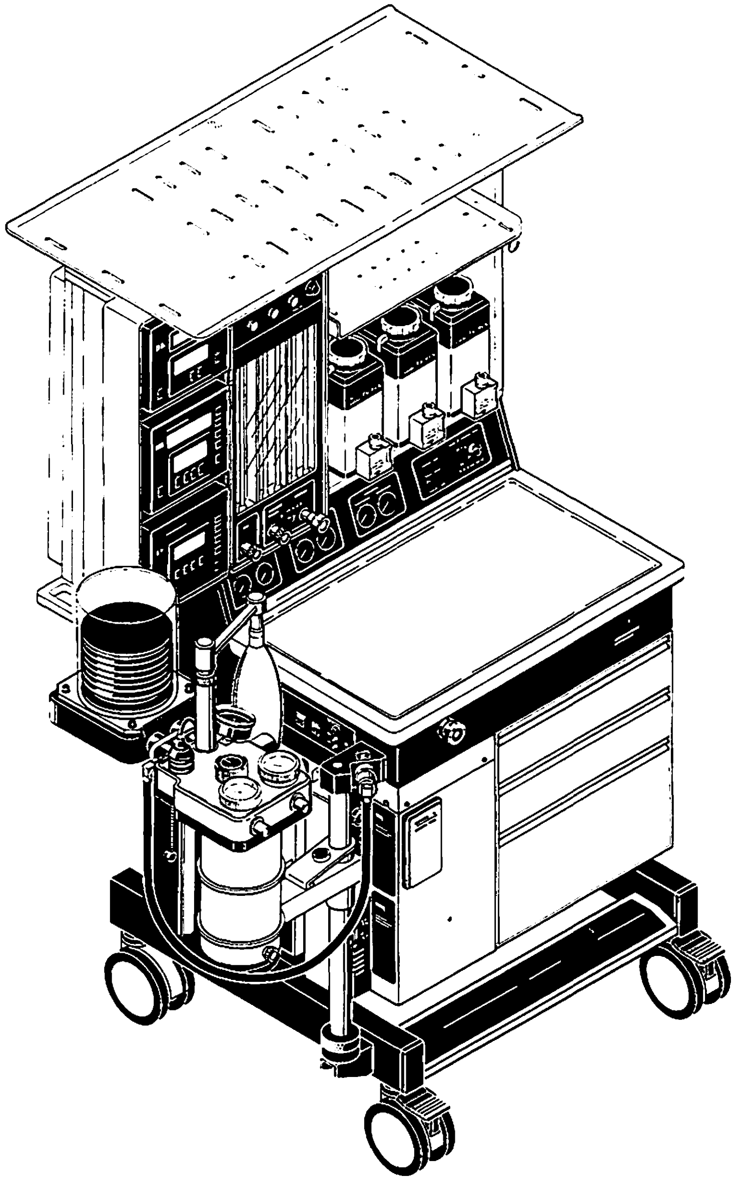
Modulus II Plus Anesthesia System

Operation and Maintenance Manual

7810 Ventilator Software Version 4.XX



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Modulus II Plus Anesthesia System
Operation and Maintenance Manual
Ohmeda 7810 Ventilator Software version 4.XX

BOC Health Care 0178-1771-000 10/93

User Responsibility

This Product will perform in conformity with the description thereof contained in this operating manual and accompanying labels and/or inserts, when assembled, operated, maintained and repaired in accordance with the instructions provided. This Product must be checked periodically. A defective Product should not be used. Parts that are broken, missing, plainly worn, distorted or contaminated should be replaced immediately. Should such repair or replacement become necessary, Ohmeda recommends that a telephonic or written request for service advice be made to the nearest Ohmeda Regional Service Center. This Product or any of its parts should not be repaired other than in accordance with written instructions provided by Ohmeda and by Ohmeda trained personnel. The Product must not be altered without the prior written approval of Ohmeda's Safety Department. The user of this Product shall have the sole responsibility for any malfunction which results from improper use, faulty maintenance, improper repair, damage, or alteration by anyone other than Ohmeda.

⚠ **CAUTION: Federal law in U.S.A. and Canada restricts this device to sale by or on the order of a licensed medical practitioner.**

Repair Policy

Do not use malfunctioning equipment. Make all necessary repairs, or have the equipment serviced by an authorized Ohmeda Service Representative. After repair, test the equipment to ensure that it is functioning properly, in accordance with the manufacturer's published specifications.

To ensure full reliability, have all repairs and service done by an authorized Ohmeda Representative. If this cannot be done, replacement and maintenance of those parts listed in this manual may be undertaken by a competent, trained individual having experience in the repair of the Ohmeda Modulus II Plus Anesthesia System and having appropriate test and calibration equipment.

⚠ **CAUTION: No repair should ever be undertaken or attempted by anyone not having proper qualifications and equipment.**

It is recommended that you replace damaged parts with components manufactured or sold by Ohmeda. After any repair work, test the unit to ascertain that it complies with the manufacturer's published specifications.

In some cases, special diagnostic equipment may be required to properly service components of the Ohmeda Modulus II Plus Anesthesia System. The components must then be sent to the nearest Ohmeda Service Center.

Contact the nearest Ohmeda Service Center for service assistance. If you send any unit to an Ohmeda Service Center, package it securely in the original shipping container, if possible, and ship it prepaid. Enclose a letter with the unit, providing a contact person's name, describing in detail any difficulties experienced and the repairs felt necessary. In all cases, other than where Ohmeda's warranty is applicable, repairs will be made at Ohmeda's current list price for the replacement part(s) plus a reasonable labor charge.

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Notes:

1/Introduction

This operation and maintenance manual is written to cover the operation and maintenance of several, similar international anesthesia/7810 Ventilator systems. Various countries or geographic regions require systems that meet different standards unique to that locale.

Ohmeda Modulus II Plus Anesthesia/7810 Ventilator System model differences and variances by country

	U.S. 3-gas	Canada 3-gas	Canada 4-gas	Japan	SE Asia	South Africa
Ohmeda System No.	1010-9009-000	1010-9008-000	1010-9014-000	1010-9002-000	1010-9006-000	0236-5452-910
3-Gas w/Air	■	■		■	■	
4-Gas w/Air, He			■			
4-Gas Air-pipeline only & CO_2 cylinder only						■
Backlit Flowmeters	■	■	■			■
CSA Approval		■	■			
Gas colors ISO		■	■			■
CEE-22 Outlets					■	■
Pipeline connection	DISS Male	DISS Hand-I-Twist	DISS Hand-I-Twist	DISS Male	DISS Male	DISS Male
Pri. Reg relief valve setting 85 psi (586 kPa)				■	■	■
Pri. Reg relief valve setting 75 psi (518 kPa)	■	■	■			
Primary Regulator Setting at 40 psi (276 kPa)	■	■	■			
Primary Regulator Setting at 50 psi (345 kPa)				■	■	■
Volts alternating current	120 V	120 V	120 V	100 V	220 V	220-250 V
Wall Gas Pressure 50 psi (345 kPa)	■	■	■			
Wall Gas Pressure 60 psi (413 kPa)		■		■	■	■
Warning Labels, French/English		■	■			
Waste Gas Evac System Standard	■	■	■			

Ohmeda complies with these differences when manufacturing international anesthesia/7810 systems and this manual covers those systems listed in the preceding matrix. The matrix provides you with a brief summary of the unique system differences by region. Differences are covered appropriately throughout the text and are indicated as they arise and create system operation/functional differences by left-margin prompters.

The system is intended for adult and pediatric applications

Its features include:

- a vaporizer interlock,
- a back-up battery (for temporary continued ventilation during power failures),
- extensive storage space on two shelves and in three drawers;
- optional, integrated monitoring;

Ohmeda Proportion Limiting Control System, which helps ensure that any oxygen/nitrous-oxide mixture delivered at the common gas outlet contains a minimum oxygen content.

Included as an integral part of the system is an Ohmeda 7810 Ventilator. This instrument combines an electronically-controlled, pneumatically-driven ventilator with built-in monitoring for exhaled volume, inspired oxygen concentration, and airway pressure. The ventilator also features controls with clinically significant ranges, selectable inspiratory pause, and an adjustable, inspiratory pressure limit control.

Before using the Ohmeda Modulus II Plus Anesthesia/7810 Ventilator System, familiarize yourself with the system by reading through this entire manual. Also read the manuals for any optional monitors and accessories, such as the Ohmeda GMS Absorber, installed in the system.

Pay special attention to the **WARNINGS** and **CAUTIONS** that appear throughout this manual. Warnings alert you to conditions or actions that may cause harm to patients or operators. Cautions alert you to conditions or actions that may result in damage to equipment.

Read the User Responsibility statement; it describes what is expected of you to maintain the system.

Read the Warranty; it describes Ohmeda's responsibility in case of a functional defect.

Keep this manual with the system for answering questions that arise about the system's operation, maintenance or, if necessary, repair.

1/Introduction

How To Use This Manual

The following symbols are used on Ohmeda products and technical manuals. No one product or manual has every symbol listed. Refer to this listing concerning symbols found on various products and manuals.

|	**On (power)**
○	**OFF (power)**
⏻	**Stand-by**
Ȯ	**Stand-by or preparatory state for a part of the equipment**
⊙	**ON only for part of the equipment**
○̇	**"OFF" only for part of the equipment**
⎓	**Direct Current**
∿	**Alternating Current**
(⏚)	**Protective earth ground**
⏚	**Earth ground**
⊥	**Frame or chassis ground**
⊠	**Alarm silence button**
▽	**Equipotential**
⊿	**Variability**
▁▂▃	**Variability in steps**
⇈	**Indicates up direction**
+	**Plus, positive polarity**
−	**Minus, negative polarity**
☼	**Lamp, lighting, illumination**
→	**Movement in one direction**
↔	**Movement in both directions**
🔒	**Lock**
🔓	**Unlock**
🚫	**non-autoclavable**
🧍	**Type B equipment**
[🧍]	**Type BF equipment**
[♥]	**Type CF equipment**
△	**Warning, ISO 7000-0085**
⚠	**Caution, ISO 7000-0434**
⚠ ▲	**Attention, consult accompanying documents, IEC 601-1**
ϟ	**Dangerous voltage**
→○	**Input**
←○	**Output**

Use this manual both as a guide to follow when you are learning to operate the Ohmeda Modulus II Plus Anesthesia/7810 Ventilator System, and as a reference tool once you are familiar with the system.

In the left margin you will find prompters for various operational/functional information including country specific differences from the base system. Unless otherwise indicated, textual information pertains to all International Modulus II Plus Anesthesia/7810 Ventilator systems.

If you are setting up the system for the first time, refer to all of the sections starting with section two "Getting Started."

If the system is already in place, but you haven't used it before, pay particular attention to all of the sections starting with section three "General Information."

If you have used the Ohmeda Modulus II Plus Anesthesia/7810 Ventilator System before, but need reminding about details of using the system, refer to sections four "Preoperative Setup Procedures" and five "Operating The System."

Sections six, "Maintaining The System" and seven, "Service Procedures," are included to inform you about routine maintenance of the system and to help you solve problems that might occur with the system.

No matter which part of the manual you are using, you should always be familiar with the Cautions and Warnings as they are used through out the manual.

Many of the sections in this manual apply only when the Ohmeda Modulus II Plus Anesthesia/7810 Ventilator System is used with the Ohmeda GMS Absorber™; if you plan to use this system with a different absorber or other anesthesia-system accessories, consult Ohmeda for more information.

What we mean by "powering ON" the control module

In this manual, when we say "power ON" the control module, use the anesthesia system's master switch.

Left side/ right side

Throughout this manual, the terms "left side" or "right side" are used to refer to locations of devices as you face the anesthesia machine. For example, the common gas outlet, which – when you face the front of anesthesia machine – is on your left, is said to be on the system's left side. And the a-c electrical outlets, which—as you face the back of the anesthesia machine—are on your right, are said to be on the system's right side.

Right-hand and Left-hand systems and referred to in the manual. This reference is to distinguish the differences in flowmeter, flow control valves, and gas supply modules (blocks) with their gauges.

Left-hand means that the oxygen gauge and oxygen flow control valve are located to the left-hand side of the appropriate set of gauges or valves.

Left-hand gauge and flow control valve layout order:
O_2 N_2O Air

Right-hand means that the oxygen gauge and oxygen flow control valve are located to the right-hand side of the appropriate set of gauges or valves. Right-hand gauge and flow control valve layout order:

Right-hand gauge and flow control valve layout order:
Air N_2O O_2

To further clarify the instruction messages that appear on the ventilator's screen are represented by a dot-matrix typeface that simulates the messages' actual appearance. A low minute volume alarm message will look like this:

`LOW MINUTE VOL!`

The system's alarm silence key is represented in a typeface similar to the one printed on the key itself. An instruction to push the key looks like this:
Press: 🔇

We have also used—both in the manual and on the 7810 Ventilator itself—symbols to represent some common terms. These symbols include:

T_{IP}	inspiratory pause
25%	**T_I** Enable inspiratory pause at 25% of inspiratory time
$\dot{V}_E$	minute volume
V_T	tidal volume
f	frequency
I:E	Inspiratory to Expiratory ratio
E	Expiratory time
I	Inspiratory time
C	Compliance
PIP	Peak Inspiratory Pressure

Notes:

2/Getting Started

Confirm that your system is set-up properly

Read through the "Getting Started" section to confirm that your system is set-up properly. Perform any steps necessary to properly connect your system's components.

The following section tells you how to prepare the system, and how to make the gas connections. These steps should be performed only by someone experienced in working with anesthesia and monitoring equipment.

2.1 Unpacking

Upon delivery

Upon delivery, inspect the system and its accessories for signs of damage that may have occurred during shipment. Before opening the shipping carton, check the tip indicator to ensure that the system was not tipped unacceptably during shipping. If you do find any damage, immediately notify the transportation company and file a damage claim. Save the original shipping container and materials, and all manuals and instructions.

Expedite the system's initial checkout

The Ohmeda Modulus II Plus Anesthesia/7810 System's functions should be completely checked as soon as possible. Use the instructions provided in this section and in any accessory instructions to install the system. Then, after you have used this manual to familiarize yourself with the System, confirm that it is working correctly by performing the preoperative checkout procedures described in section "4/Preoperative Checkout Procedures".

Before using the system with a patient, always check each item on the Preoperative Checklists, found in the front of this binder.

2.2 Installing the Ohmeda GMS Absorber

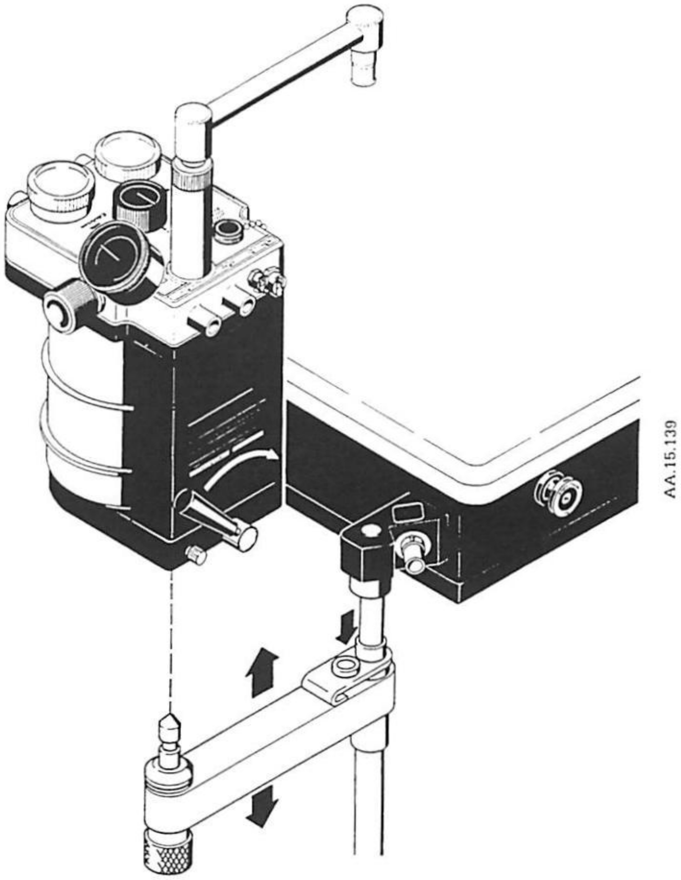
If you are using a different type of absorber, refer to its specific operation manual for installation instructions. Install the absorber mounting pin kit, which must be ordered separately for the absorber mounting arm.

1. Turn the absorber mount release, which is next to the absorber's canister locking lever, counterclockwise as far as it will go. (See figure 2-1.)

2. The anesthesia machine's swivel arm supports the absorber. Place the absorber on the arm's mounting pin.

3. Turn the absorber mount release clockwise until it is tight, being careful not to over-tighten.

Figure 2-1
Mounting the absorber



2.3 Connecting the Bellows Assembly

This section describes how to use the absorber interface manifold to connect the bellows assembly to the Ohmeda GMS Absorber. If you plan to mount the bellows assembly on an anesthesia system's side mount rather than on the Ohmeda GMS absorber, refer to Appendix 9-E.

Note: For information on Ohmeda's Autoclavable Bellows Assembly (ABA), see section 8 of this manual. The mounting plate and the base of the ABA are compatible with the mounting hardware for the non-autoclavable bellows assemblies.

Connecting the Bellows Assembly to the Absorber

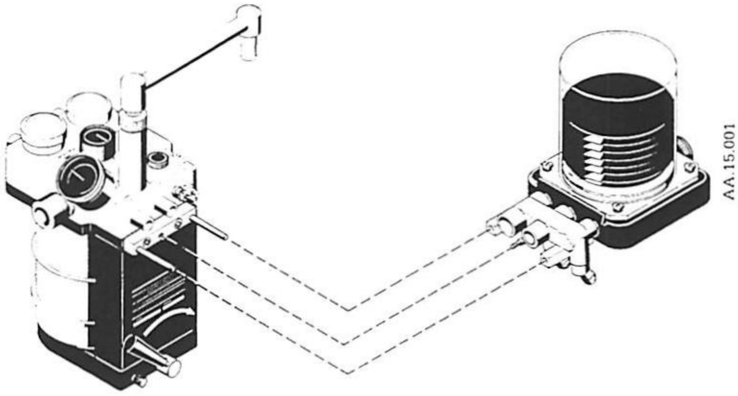
1. Align the two square-shaped support guides on the bottom of the bellows assembly with the two support pins on the back of the absorber. (See figure 2-5.)

2. Align the support pins with the support guides and slide the bellows assembly toward the absorber until the interface manifold touches the absorber's ports.

3. Align the bellows assembly's locking rod with the threaded hole between the two screws on the absorber's support-pin block.

4. Turn the bellows assembly's locking knob clockwise until the absorber interface manifold is securely connected to the absorber and the knob won't turn further.

Figure 2-2
Connecting the bellows assembly to the absorber



Connecting the Bellows Assembly to the Ventilator Control Module

1. A corrugated tube carries drive gas from the control module to the bellows assembly. Connect one end of this tube with the 90-degree adapter to the control module. The adapter has an internal O-ring; make sure it is in place.

2. Use the set screws on the adapter to secure it to the connector on the control module's rear panel. (See figure 2-6.)

3. Hanger tabs bundle the corrugated tube and the clear pressure-sensing tube. Lead the corrugated tube through the larger ring on each hanger tab. Position the hanger tabs evenly along the corrugated tube.

Figure 2-3
Connecting the drive-gas tube to the control module

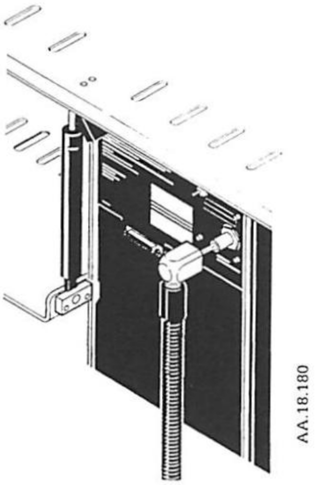


Figure 2-4
Connecting the drive-gas tube to the absorber interface manifold

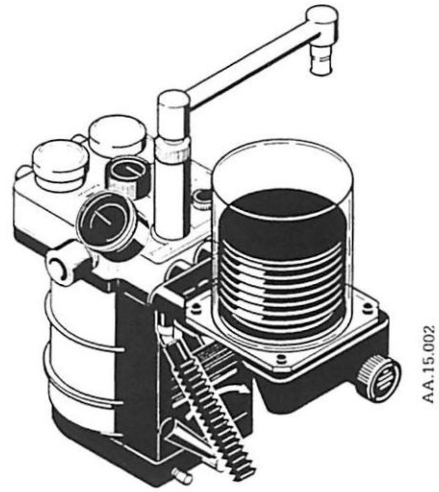
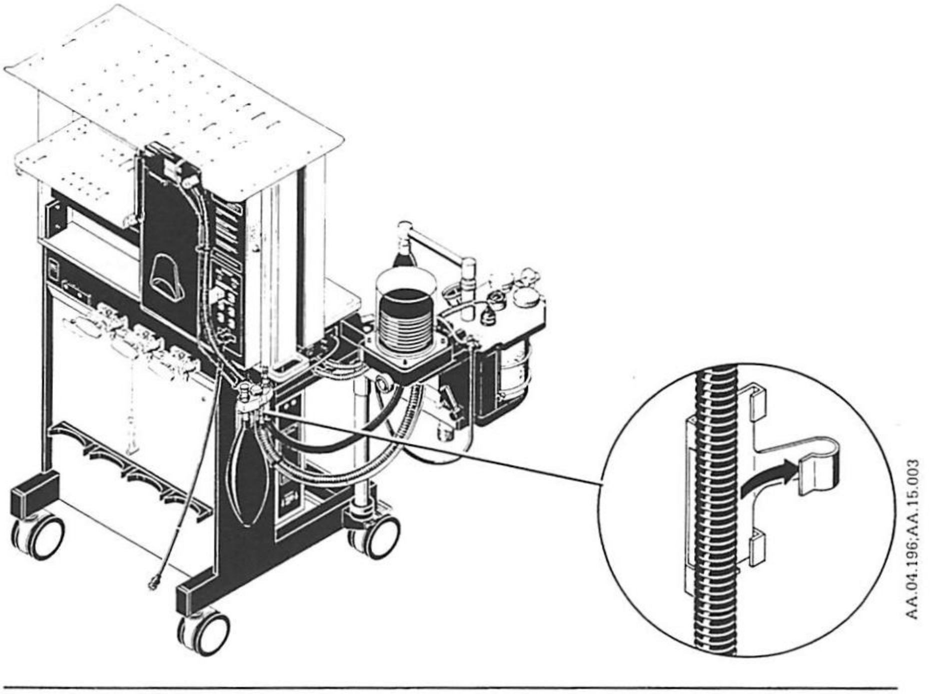


Figure 2-5
Attaching the drive-gas tube to the mounting bracket



4. Connect the free end of the corrugated tube to the absorber interface manifold barbed connector. (See figure 2-7.)

5. The bracket mounted on the anesthesia machine main-frame secures the drive gas tube to the side of the machine. Insert the corrugated tube into the clip. (See figure 2-8.)

2.4 Making the Monitoring Connections

Connecting the Pressure Sensing Tube

Pressure sensor connections with GMS absorber

The airway pressure sensor is housed in the ventilator control module. A clear, 3 mm (1/8 in.) tube connects the control module to the distal-sensing tee in the inspiratory limb of the breathing system, or for GMS Absorbers, under the absorber's pressure gauge.

1. A barbed connector under the absorber's pressure gauge provides the distal-sensing port for the ventilator's pressure sensor. Slide one end of the sensing tube onto the tee's barbed fitting under the gauge. (See figure 2-9.)
2. String the other end of the sensing tube through the small holes in the hanger tabs that are attached to the drive gas tube.
3. Slide the tube's free end onto the barbed connector marked "Connect to Inspiratory Limb of the Breathing Circuit" on the control module's rear panel. (See figure 2-10.)

WARNING: Position the pressure-sensing tube so that the absorber arm cannot pinch the tube. If the tube is pinched, the system's pressure monitoring will not function correctly.

Connect the sensing tee to the inspiratory limb of the breathing circuit

For pressure monitoring to function correctly, the distal-sensing tee must connect to the inspiratory side of the breathing system. All Ohmeda GMS Absorbers presently manufactured have their pressure gauges connected to the inspiratory side, however certain older, unmodified Ohmeda GMS Absorbers have their pressure gauges connected to the expiratory side of the breathing system. This modification can be installed on older Ohmeda GMS Absorbers with an upgrade kit. If you are not sure that your absorber's pressure gauge—and distal sensing tee—is in the inspiratory side of the breathing system, perform the test in Appendix 9-F.

If you want to use the ventilator without an Ohmeda GMS absorber, you must install an optional, in-line, pressure-sensing tee in the inspiratory limb of the breathing system. (See Appendix 9-D.)

Figure 2-6
Connecting the pressure-sensing tube to the absorber's pressure gauge

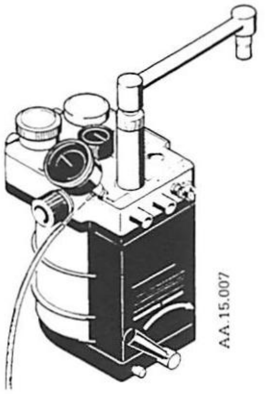
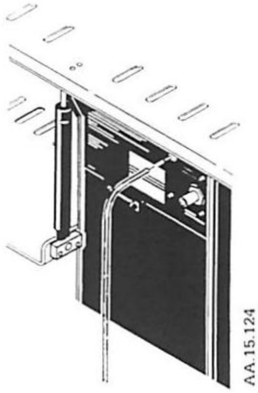


Figure 2-7
Connecting the pressure-sensing tube to the control module



Connecting the Volume Sensor

To provide information about the volume of each exhaled patient breath, the ventilator measures the amount of gas that passes through a sensor inserted in the breathing system. The ventilator makes calculations based on this measurement and then displays the calculated tidal volume, minute volume, and breath rate.

The volume sensor assembly includes a cartridge with a vane whose rotational speed varies depending on the gas flow rate, and a sensor clip that translates the direction and speed of the vane's rotation into electrical pulses. This cartridge must be placed in the expiratory limb of the breathing system, either in the distal or proximal position.

WARNING: When the volume sensor is in the distal position of the breathing circuit, confirm that the reverse-flow alarm is enabled. The reverse flow alarm will function properly only when it is in proper working order and is located in the distal position of the expiratory limb of the breathing system. Do not use the system with the reverse-flow alarm disabled if the volume sensor is in the distal position.

Place the volume sensor in the expiratory limb of the breathing circuit

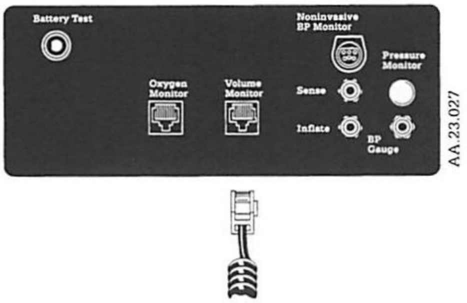
Placing the cartridge at the distal position in the expiratory limb lets the system detect reverse flow and generate reverse flow alarms. You may also place the volume sensor cartridge at the proximal end of the "Y" connector; however, you then must use the ventilator Setup Page to disable the reverse flow alarms that would otherwise be generated when the patient inhales. If you are using a Bain circuit and Bain circuit adapter, the volume sensor cartridge must be placed in the proximal position, between the end of the Bain circuit and the patient connector to the ET (endotracheal tube) or mask. (See Appendix 9-H for details about the volume sensor assembly with a Bain circuit)

WARNING: Condensate water in the volume sensor transducer cartridge will restrict vane motion and cause erroneous monitor readings. Position the tubing so that any condensation water drains away and does not accumulate in the cartridge.

Install the volume sensor

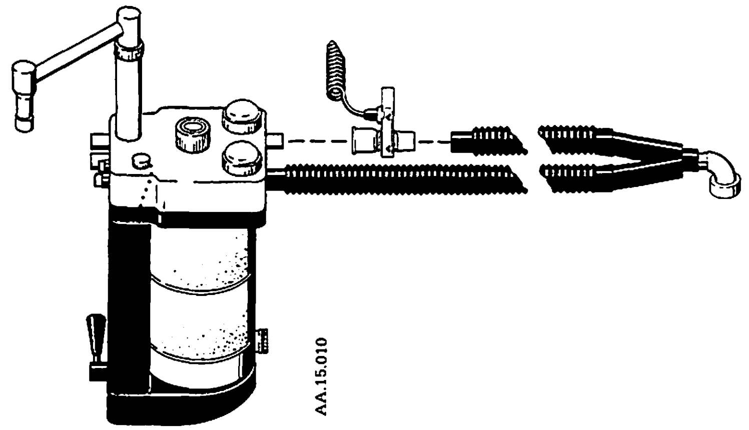
1. Connect the sensor cable to the receptacle marked "Volume Monitor" on the anesthesia machine's patient interface panel.

Figure 2-8 Connecting the volume sensor into the patient interface panel



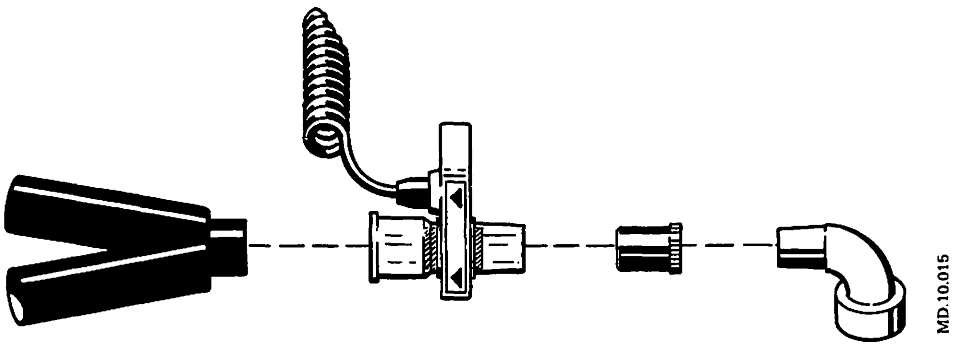
2. Install the sensor cartridge between the absorber's exhalation port and the expiratory limb of the breathing system.

Figure 2-9
Inserting the volume sensor cartridge at the distal location of the breathing system's expiratory limb



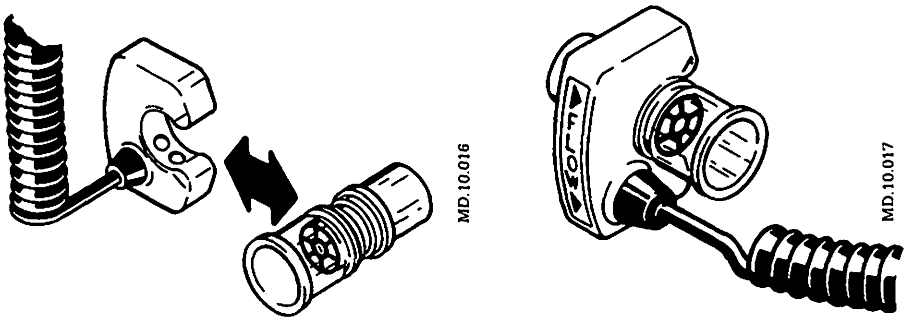
You may also install the cartridge at the proximal end of the "Y" connector.

Figure 2-10
Inserting the volume sensor cartridge at the proximal end of the "Y" connector



3. Clip the sensor over the cartridge. The arrows on the sensor must point in the direction of gas flow during exhalation; the arrows must point toward the absorber and away from the patient.

Figure 2-11
Attaching the volume sensor cartridge to its clip, note the directional arrows



4. Check the volume sensor as described in Preoperative Checkout Section 4.

WARNING: Take care not to crack or break the volume sensor cartridge. The cartridge is tapered to help ensure a tight fit onto the absorber. Gentle, firm pressure should be sufficient to obtain a secure fit—do not force the cartridge in place as tightly as possible. Avoid striking the cartridge. A broken or cracked cartridge could cause a circuit disconnection and a break in the breathing system.

WARNING: The volume sensor and cartridge must be correctly installed at either the distal location in the breathing system's expiratory limb or the proximal end of the "Y" connector. If the sensor and cartridge are installed incorrectly, volume data will be inaccurate and associated alarms, including the apnea and low minute volume alarms, will not function properly.

WARNING: Destroy old or malfunctioning volume sensor cartridges to prevent inadvertent reuse. Using malfunctioning volume sensor cartridges may result in compromised patient data.

WARNING: Position the volume sensor cable so that the absorber arm cannot pinch the cable. If the cable is pinched, the system's volume monitoring may not function correctly.

Connecting the Oxygen Sensor

Connect the probe cable to the patient interface panel, and insert the probe into the Ohmeda GMS Absorber. If you want to use the ventilator without an Ohmeda GMS absorber, you must install an optional, in-line oxygen-sensor adapter in the inspiratory side of the breathing system. (See Appendix 9-D.)

WARNING: Use protective gloves and eye-wear when you open the O_2 sensor in case the cartridge is leaking. The sensor cartridge contains potassium hydroxide (caustic).

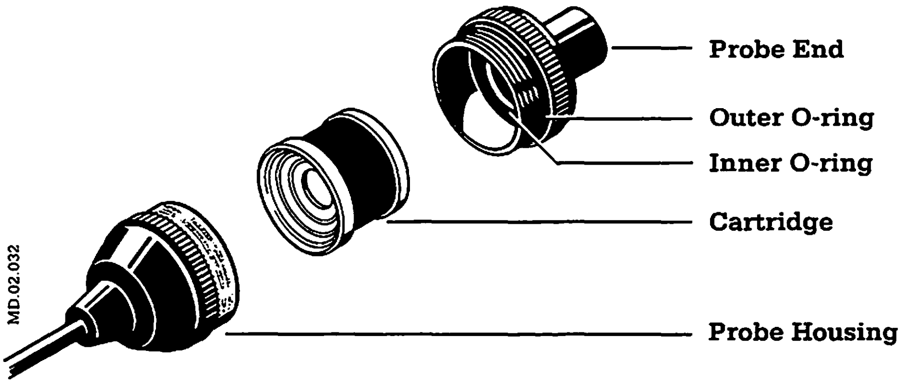
Oxygen sensor assembly

1. The actual oxygen sensing device is a cartridge that you must install in the oxygen probe before you insert the probe into the absorber. To install the oxygen probe's cartridge:
    a. Hold the probe housing so the cable hangs down and the probe points up.
    b. Grasp the housing's knurled surfaces and turn the housing's probe end counterclockwise until it is free.
    c. Set the probe section aside.

CAUTION: Do not remove oxygen sensor cartridges from their protective packaging until just before you install the cartridges. Oxygen sensor cartridges left exposed to room air may develop an oxide coating that can temporarily degrade oxygen-monitoring performance.

    d. Remove an oxygen sensor cartridge from its protective package. This package contains an inert atmosphere intended to prolong the cartridge's shelf life. Do not remove the cartridge from its package until you are ready to install it.

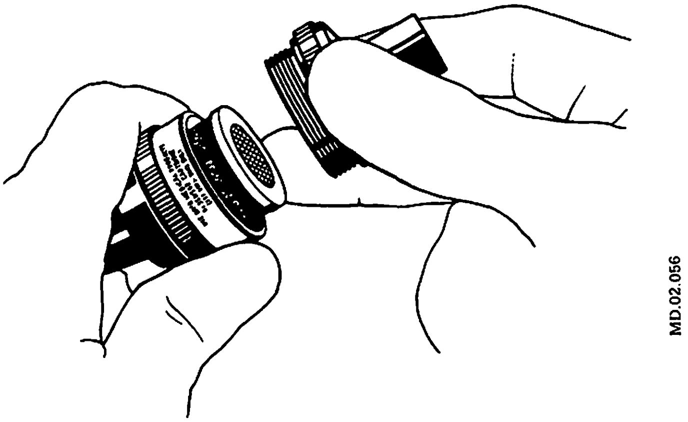
Figure 2-12 The oxygen sensor, exploded view



e. Remove the shorting clip or disk and insert the cartridge so its screen faces out of the housing, and so the three metallic, concentric rings at its other end contact the gold-colored terminals at the cable end of the probe housing.

f. Thread the housing's probe section back onto the cable section. Turn the probe section until it is finger tight. Make certain the sections are tight enough to compress the housing's O-rings, which form a gas-tight seal.

Figure 2-13 Reassembling the oxygen probe



2. Connect the sensor cable to the receptacle marked "Oxygen Monitor" on the anesthesia machine's patient interface panel.
3. Remove the cap from the absorber's oxygen sensor port, which is labeled "Oxygen Sensor."

4. Insert the oxygen sensor probe into the absorber's sensor port.
5. Calibrate the oxygen sensor as described in section 6, "100% O_2 Calibration."

WARNING: Always perform the calibration and preoperative checkout procedures for oxygen-sensing functions after replacing a new sensor cartridge or a recently cleaned and sterilized oxygen sensor.

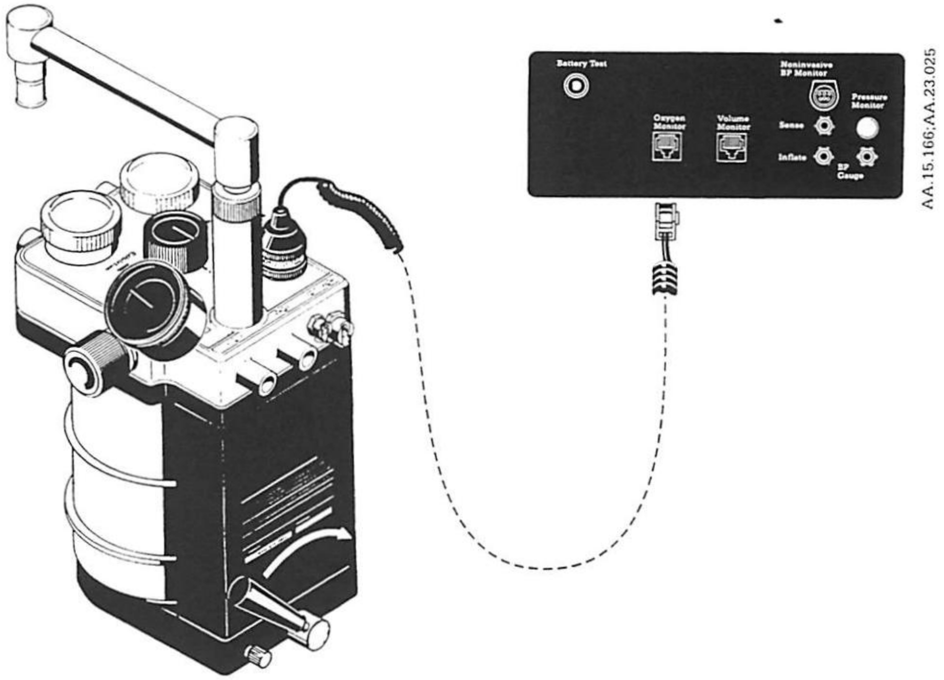


Figure 2-14
Connecting the oxygen probe to the absorber and the patient interface panel

If any part of the sensor assembly is damaged or malfunctions, replace the entire assembly. In addition, the oxygen cartridges wear out and must be periodically replaced. See section 6 for information on "Maintaining the Oxygen Sensor" and "Replacing the Oxygen Sensor Cartridge".

If, during operation, the sensor's temperature is lower than or equal to the breathing-gas dew-point temperature, water vapor condenses on the probe's sensor screen. This condensate may reduce the amount of oxygen reaching the sensor's screen and cause the ventilator to display lower than actual oxygen concentration values.

CAUTION: When in use, the oxygen sensor probe should always point down to help reduce condensation on the sensor surfaces. Condensation on the sensor may affect patient data.

WARNING: Position the oxygen sensor's cable so that the absorber arm cannot pinch the cable. If the cable is pinched, the system's oxygen monitoring may not function correctly.

2.5 Anesthesia System

Using the Shelves and Mounting Tracks

To accommodate additional monitors and other equipment, the Ohmeda Modulus II Plus Anesthesia System offers both a vertical mounting track and two horizontal shelves. The system's top shelf is a long, deep shelf, whose angle can be adjusted; and the middle shelf is a smaller, fixed shelf. Clips and straps are used to secure equipment to these shelves. Sliding brackets attach equipment to the mounting tracks, which are on the machine's sides.

WARNING: Remove all accessory equipment from the shelves before moving the anesthesia machine over bumps or on any inclined surface. Heavy top loading can cause the machine to tip over causing injury to the person moving it or to others.

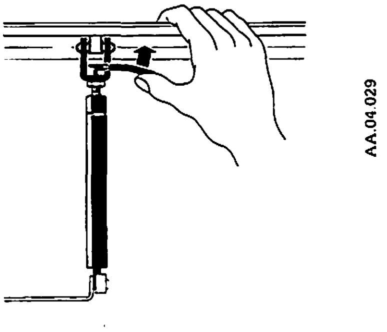
CAUTION: Do not place materials weighing more than 11.3 kg (25 lb.) on the lower, stationary shelf, or more than 27.2 kg (60 lb.) on the upper, tilting shelf. Over-loading may damage the shelves or cause instability.

CAUTION: Secure any equipment placed on the shelves. Unsecured equipment could fall and damage the equipment or cause injury to personnel.

Adjusting The Top Shelf's Angle

A latching strut lets you adjust the top shelf's angle. To increase the angle, grasp the shelf at the rear near the strut and use your thumb to squeeze the strut's lever. To decrease the shelf's angle, squeeze the lever and pull down on the shelf. When the shelf has reached the position you want to use, release the lever.

Figure 2-15
Releasing the top shelf's latching strut



Securing Equipment on the Shelves

1. If mounting equipment on the top shelf, make sure it is level.
2. Set a single piece of equipment in place on a shelf.
3. The slots in the shelves are designed to accept the mounting clips, with a pair fitting into each slot. In the slot nearest to the left edge of the piece of equipment, place a clip with its curved side facing the equipment.

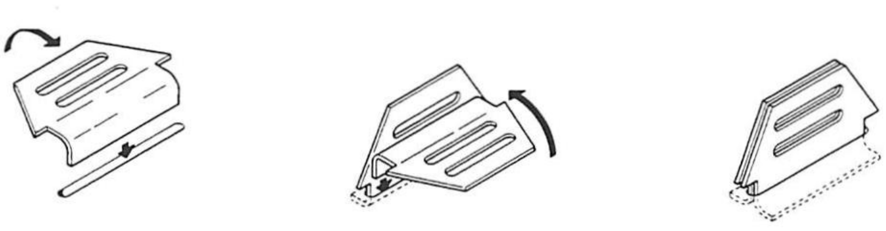
Mounting the clips and straps

4. Next to the first clip, place a second clip with its curved side away from the equipment you are mounting.

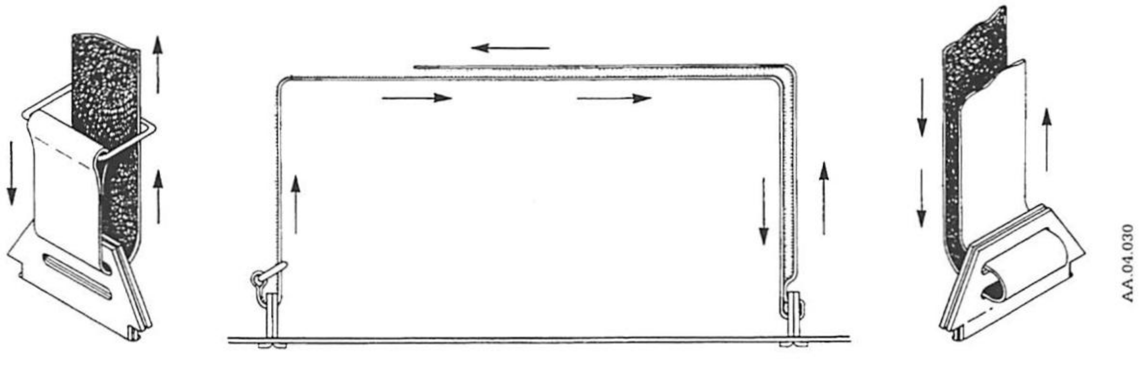
5. Place a second pair of clips in the slot nearest the right edge of the piece of equipment.

6. Thread the mounting strap through the clips as illustrated in either figure 2-19B or figure 2-19C, depending on the size of the equipment you are securing.

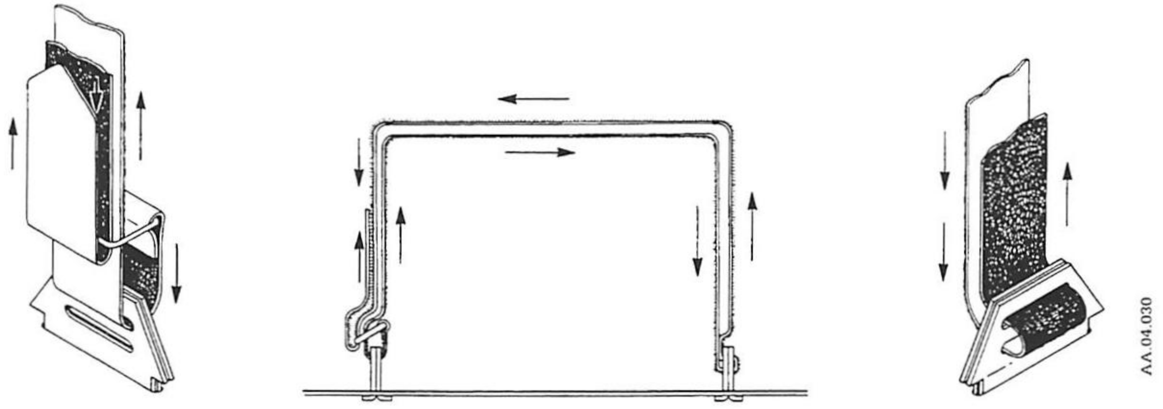
Figure 2-16
A, B, & C
Adjusting the
shelves' straps



A---Place clips in slots on each side of the equipment



B---Adjust the straps according the size and weight of the equipment



C---Secure the strap ends

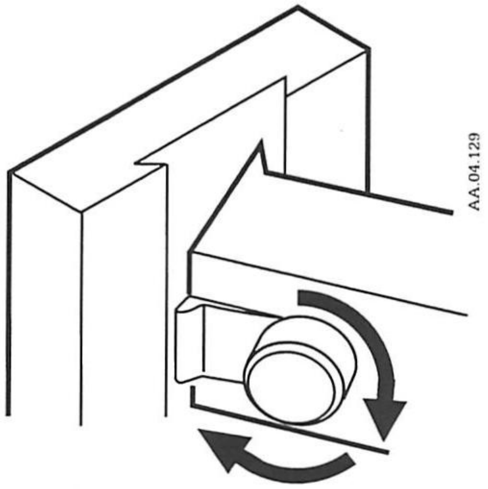
Securing Equipment on the Mounting Tracks

On the anesthesia machine's sides are the vertical mounting tracks, which accept brackets intended for optional equipment, such as accessory shelves and IV poles (see Appendix 9-B for optional accessories).

Installing a mounting bracket in a mounting track

1. Turn the bracket knob counterclockwise until the lip on the hinged portion retracts.

Figure 2-17
Installing a mounting bracket on the vertical track



2. Fit the bracket's mounting surface into the mounting track so the bracket lip fits into a mounting track groove.
3. Slide the bracket into the position you want to use.
4. Turn the bracket knob clockwise to secure the bracket in the track.

Installing the Gas Cylinders

Each of the pipeline gases your system uses can be backed up by either "D" or "E" size gas cylinders, mounted upon the yokes on the back of the anesthesia machine. During normal operation, when your hospital's pipelines are supplying gas, keep the cylinder valves closed. If a pipeline supply fails, use the cylinder wrench included to open the appropriate cylinder.

WARNING: Do not leave gas cylinder valves open if the pipeline supply is in use and the system master switch is turned to "On." Pressures from both supplies may become equal and, if simultaneously used, cylinder supplies could be depleted, leaving an insufficient reserve supply in case of pipeline failure.

CAUTION: To avoid stripping threads, do not use wrenches on the yoke gate tee screws.

CAUTION: Always use a yoke plug and cylinder gasket to seal any unused yokes. Yoke check valves alone may not provide a leak-free seal.

1. Turn the system master switch to OFF.
2. Give the yoke gate tee handle a slight rap with the palm of your hand. Then swing the right end of the gate up and over to your left.
3. Turn the tee handle counterclockwise until the tip of the screw is flush with the inside surface of the gate.
4. Remove any used gaskets from the yoke strainer nipple.
5. Install a fresh gasket on the nipple.

CAUTION: Use only one cylinder gasket per yoke. Using more than one gasket can cause cylinder gas leakage or can defeat the pin index system.

6. Before installing a cylinder in the yoke, remove the dust cap (if one is installed) from the cylinder valve.
7. To clear the cylinder valve of any debris, use the cylinder wrench to briefly open, then close the cylinder.

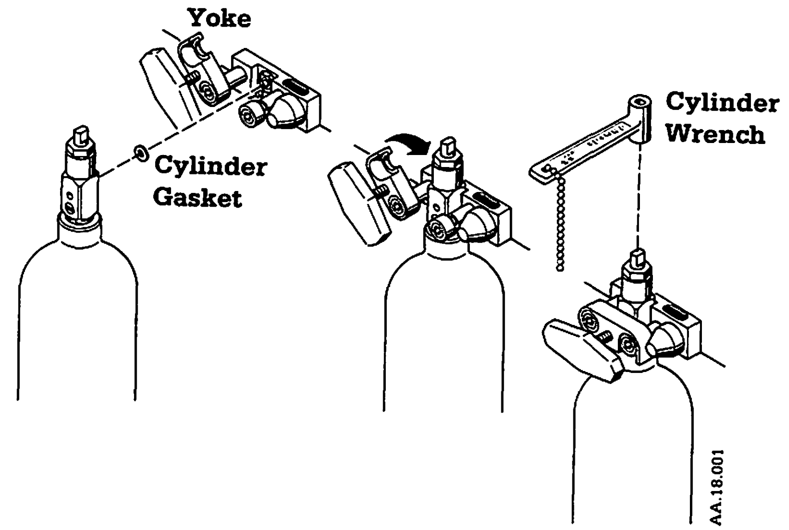
WARNING: Remain clear of exiting gases while opening and closing the cylinder valves to purge debris.

8. Align and engage the holes in the cylinder post with the safety index pins and strainer nipple.

9. Swing the gate closed and, by hand, tighten the tee handle to hold the cylinder firmly in place. The gate locks shut to help prevent accidental opening.

CAUTION: Open cylinder valves s-l-o-w-l-y to avoid damaging the regulators.

Figure 2-18
Installing the cylinders



10. Check for leaks.

    a. Disconnect the pipeline gas supply.

    b. Open, then close, the cylinder valve.

    c. Watch the cylinder pressure gauge; if the pressure drops more than 100 psig (690 kPa) in five minutes, the high-pressure circuit has an unacceptable leak. Leaks may be caused by a defective cylinder gasket or loose tee handle.

    d. If the cylinder is leaking, replace the gasket and tighten the tee handle; then repeat the leak check. If the cylinder continues to leak, do not continue to use the system for clinical applications; call trained service personnel for repairs.

Installing the Vaporizers

WARNING: Simultaneous delivery of vaporized liquid anesthesia agent is possible when using vaporizers without interlocks. Use only one vaporizer at a time.

Ohmeda recommends that your institution establish a standard mounting sequence for all vaporizer manifolds in use. You can, however, mount Ohmeda Vaporizers in any order. If a Tec 6 Vaporizer is mounted to the manifold, it is recommended that it be mounted on the right-hand side of the manifold. When the Ohmeda vaporizers are properly mounted on an Ohmeda vaporizer manifold, gas flow enters only the vaporizer that is switched on. The order in which vaporizers are mounted has no effect on vaporizer performance. Refer to the Ohmeda Tec 4, Tec 5, or Tec 6 Continuous Flow Vaporizer Operation Manual for complete instructions on using the vaporizers.

To mount a vaporizer

1. Depress the control release lever and move the vaporizer control knob to OFF. (See figures 2-22 and 2-23.)

Figure 2-19
Installing a Tec 4 vaporizer

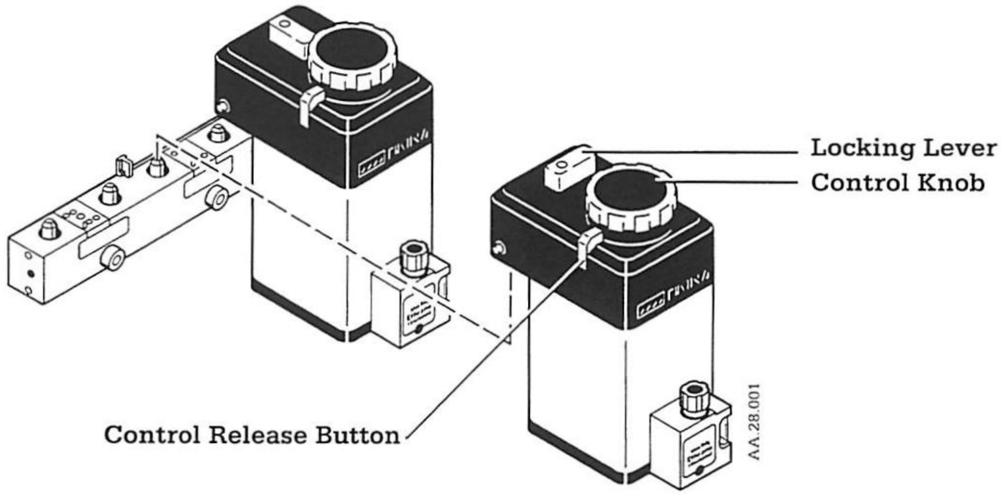
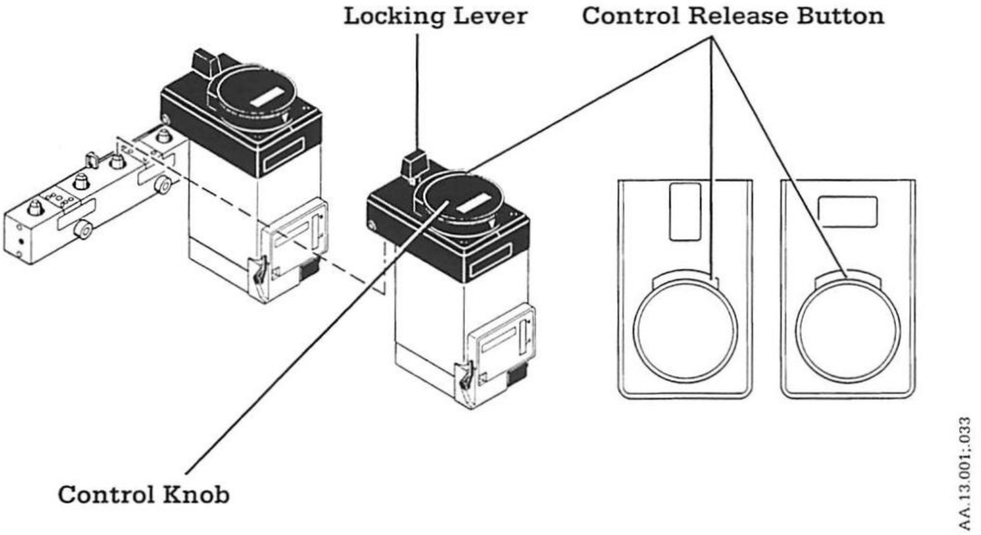

Locking Lever
Control Knob
Control Release Button
AA.28.001

Figure 2-20
Installing a Tec 5 vaporizer


Locking Lever
Control Release Button
Control Knob
AA.13.001.033

2. Turn the vaporizer locking lever, located next to the vaporizer control knob, counterclockwise as far as it will go. The locking lever is spring loaded and should be in a raised position.

3. Carefully lower the vaporizer onto the manifold so the vaporizer's interlock block covers the two manifold port valves.

4. Depress and turn the locking lever clockwise to lock the vaporizer onto the manifold. For Tec 6 vaporizers, plug in the power cord to one of the a-c outlets on the back of the gas machine.

Note: Tec 6 vaporizers should be mounted on the far right side of the vaporizer manifold and the power cord routed to the right of the Tec 6 between it and adjacent units. It on the right outboard side, around the outside right frame member of the anesthesia machine to an electrical outlet. If more than one vaporizer is used, ensure power cords do not interfere with mounting on the manifold.

Check vaporizer mounting

1. Check that the tops of all vaporizers are level and at the same height. Remount any vaporizer that is visibly misaligned.

2. When all vaporizers appear level, are at the same height, and are locked in place, gently attempt to lift each vaporizer off the manifold. Remount any vaporizer that can be lifted off the manifold.

WARNING: Do not use any vaporizer that is visibly misaligned on the manifold or that, when its lever is locked, can be lifted off the manifold. Incorrect mounting may result in incorrect delivery of gases.

To remove vaporizers

1. Move the vaporizer control knob to OFF. If the vaporizer is not switched completely off, it will not release from the manifold.

2. Turn the vaporizer locking lever fully counterclockwise to release the vaporizer. For Tec 6 vaporizers, unplug the power cord.

3. Carefully lift the vaporizer straight up and off the manifold.

Adjusting the Position of the Absorber

You can adjust the absorber's position by rotating the absorber in place on the absorber arm; by swinging the absorber arm on its mounting tube; and by adjusting the height of the arm along its mounting tube. If you want to rotate the absorber or swing the absorber's arm, just push the absorber to the position you want to use; the absorber will move freely. To keep the absorber arm from swinging too easily, tighten the knurled knob on the mounting tube, near the anesthesia machine's base.

Change the absorber position

1. A knob under the absorber's mounting pin on the arm secures the pin to the mounting track. Loosen this knob about one turn.

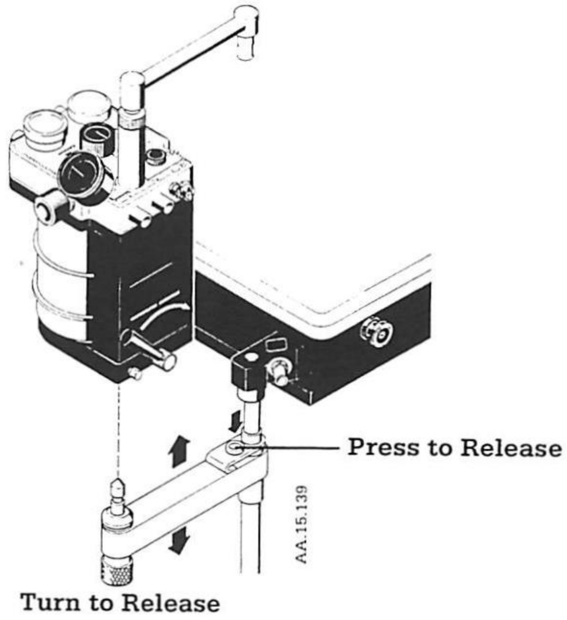
Changing the position of the absorber along the absorber arm

2. Slide the absorber to its new position.
3. Tighten the knob to lock the absorber in place on the track.

Adjust the absorber height

1. Place one hand under the absorber on the arm.
2. With your free hand, grasp the absorber swivel arm near its mounting post.
3. Use your thumb to press the vertical adjustment button on the arm's locking plate, which is mounted to the arm and post. Continue pressing the button, pull up on the absorber swivel arm, and slide the arm to the position you want to use; then release the button.

Figure 2-21
Adjusting the position of the absorber



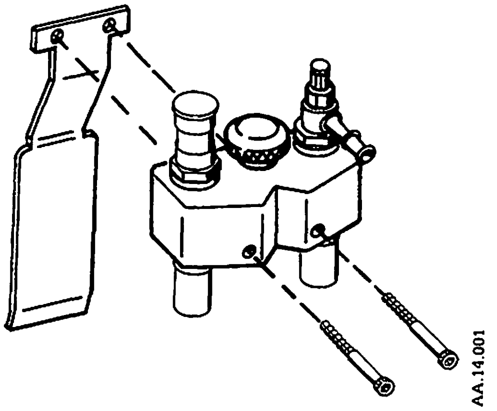
2.6 Mounting the Waste Gas Scavenging Interface Valve

The Ohmeda waste gas scavenging interface valve provides a central manifold for channeling waste gas from the breathing system to a waste-gas disposal system. You can mount this assembly in either of two locations: the left side of the anesthesia machine main-frame; or, if necessary, to the absorber swivel arm. For most applications, mounting the assembly directly to the side of the anesthesia machine main-frame is preferable; when the assembly is mounted to the absorber arm, it may contact and obstruct the use of other equipment in certain system configurations.

To mount the assembly to the side of the anesthesia machine main-frame:

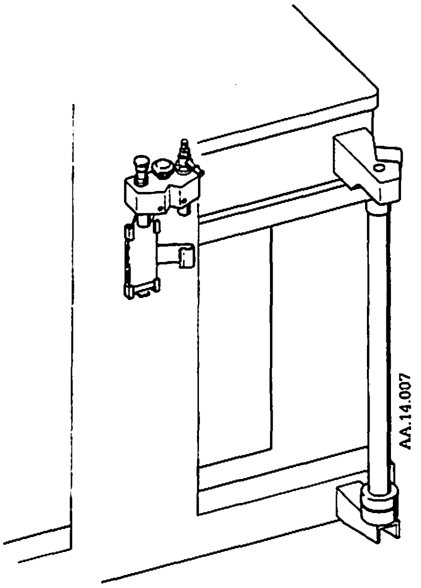
1. The assembly uses a plate that slides into a bracket mounted on the side of the anesthesia machine. Hold this plate to the valve assembly so the holes on the plate align with the holes on the assembly's long, flat rear surface. The plate must extend downward, away from the assembly's needle-valve knob.

Figure 2-22 Attaching the scavenging interface valve to its mounting plate



2. Insert the two screws through the holes on the side of the assembly opposite the mounting plate.
3. Tighten the screws.
4. The bracket mounted on the anesthesia machine serves two purposes; it secures the corrugated drive gas tube that runs from the ventilator's control module to the bellows assembly; and it attaches the valve assembly to the side of the machine. Slide the waste gas scavenging interface valve assembly onto this bracket.

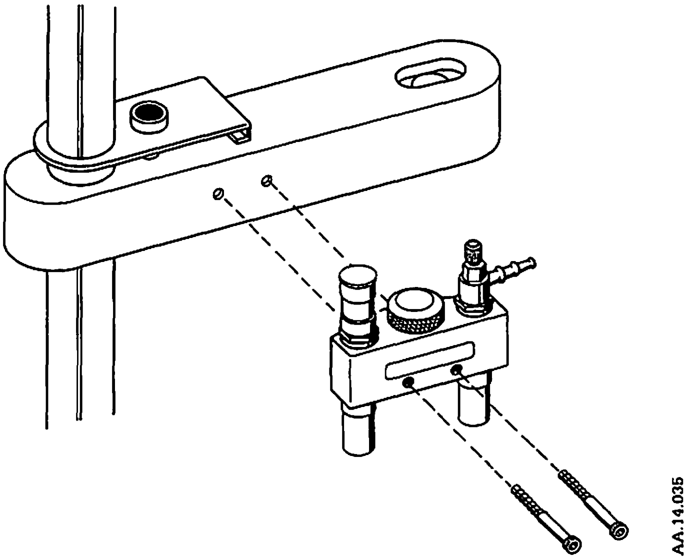
Figure 2-23 Mounting the scavenging interface valve to the side of the anesthesia machine



Mounting the assembly to the absorber arm

1. If the mounting plate is attached to the assembly, remove the two screws that hold it in place; then store the plate but retain the screws.
2. Hold the valve assembly so that its notched side faces the absorber swivel arm, and align the assembly's two holes with the two tapped holes in the arm.
3. Insert the two screws into the holes in the assembly.
4. Tighten the screws.

Figure 2-24
Mounting the scavenging interface valve to the absorber arm



2.7 Making the Anesthesia System Gas Connections

WARNING: Do not use flammable anesthetics. A possibility of explosion will exist if the system is used in the presence of flammable anesthetics.

Making the Gas Pipeline Connections

Each of the pipeline gases your system uses is introduced to the anesthesia machine through a labeled pipeline inlet. The inlets for the pipeline gases are mounted next to the corresponding gas cylinder yokes on the back of the machine.

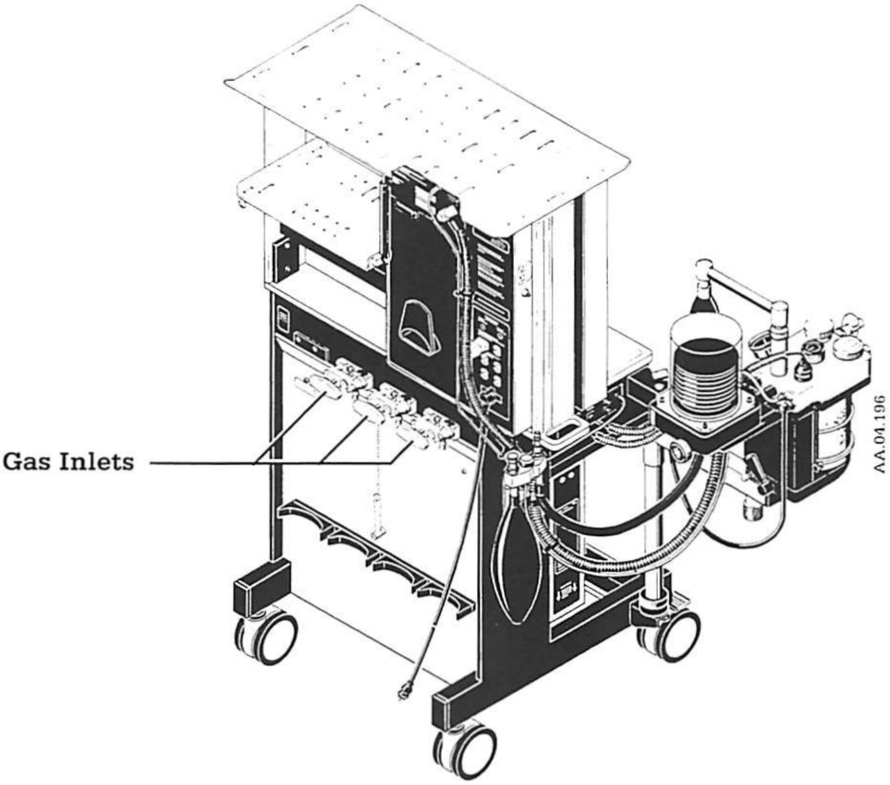
Connecting to pipeline inlets

1. If gas cylinders are installed, use the cylinder wrench to close the cylinder valves.
2. Connect the hospital's oxygen pipeline to the system's oxygen pipeline inlet, which is labeled "O_2 Pipeline Inlet."

3. Connect the hospital's nitrous oxide pipeline to the system's nitrous oxide inlet, which is labeled "N_2O Pipeline Inlet."

4. If you are using air, connect the hospital's air pipeline to the system's air inlet, which is labeled "Air Pipeline Inlet."

Figure 2-25
The gas pipeline inlets



Waste Gas Scavenging Interface Valve, Connections

Provided with the gas scavenging interface valve assembly—and marked with yellow bands—are a 19-mm bore, three-liter, disposable, reservoir bag, and lengths of yellow-banded, corrugated tubing.

⚠ **CAUTION: To help prevent operating room pollution, cap all unused connectors.**

⚠ **WARNING: Do not connect the ventilator exhaust directly to a vacuum source. The vacuum may remove required gases from the breathing system.**

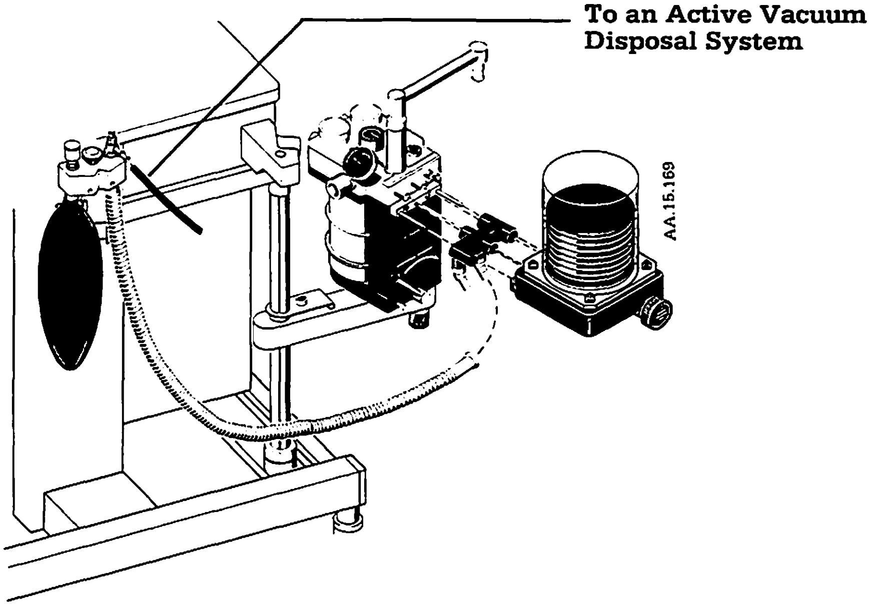
Connections to an active vacuum disposal system

Making The Waste Gas Scavenging Connections To An Active Vacuum Disposal System

1. Connect one end of a yellow-banded tube to the exhaust connector on the absorber interface manifold. (See figure 2-26.) See Appendices D, E and F for information about using the ventilator with absorbers other than Ohmeda GMS Absorbers.

2. A connector is mounted next to the waste gas scavenging interface valve on the interface valve assembly. Securely attach the free end of yellow-banded tube to an unused connector at the bottom of the assembly.

Figure 2-26
Making the gas scavenging connections to an active vacuum disposal system



3. Securely attach a three-liter reservoir bag to another unused connector of the interface valve assembly.

4. Connect a 1/4-inch ID vacuum hose to the barbed connector that extends from the side of the swivel connection on the vacuum adjustment needle valve.

5. Connect the free end of the 1/4-inch ID vacuum hose to a vacuum pipeline system that has a vacuum level of at least 245 mm Hg (10 inches Hg).

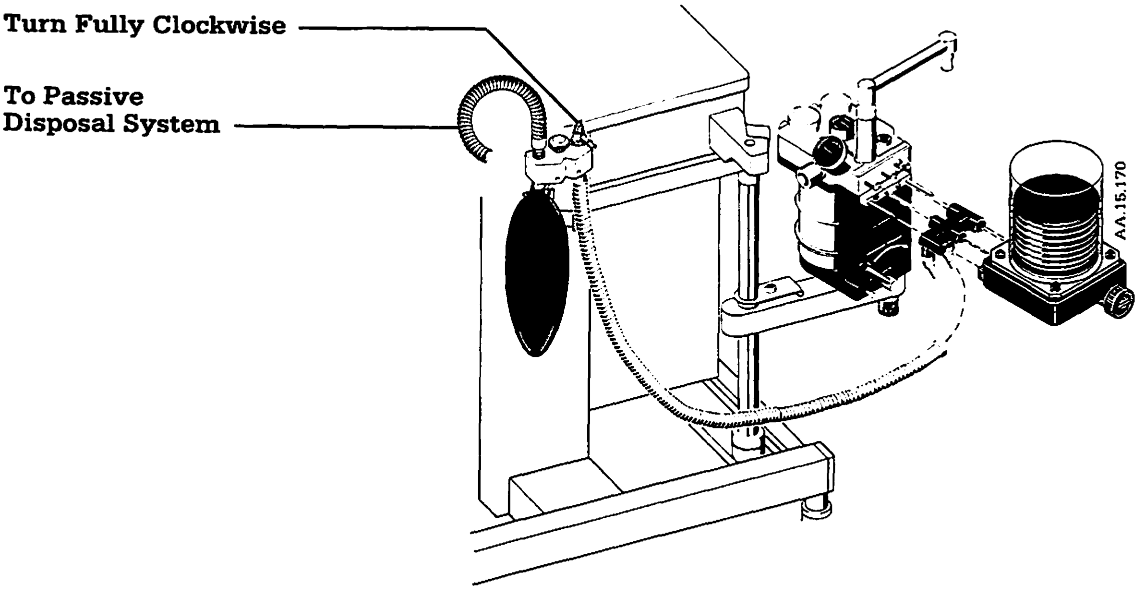
6. Cap any unused connectors of the interface valve assembly.

Connections to a passive disposal system

Making The Waste Gas Scavenging Connections To A Passive Disposal System

1. Connect one end of a yellow-banded tube to the exhaust connector on the absorber interface manifold. See Appendices D, E and F for information about using the ventilator with absorbers other than Ohmeda GMS Absorbers.
2. A connector is mounted next to the waste gas scavenging interface valve on the interface valve assembly. Securely attach the free end of yellow-banded tube to an unused connector at the bottom of the assembly.
3. Attach one end of another yellow-banded tube to an unused connector remaining on the interface valve assembly.
4. Connect the other end of the tube to the non-recirculating ventilation system.

Figure 2-27 Making the gas scavenging connections to a passive disposal system



5. Cap any unused connectors.
6. Turn the vacuum adjustment valve's knob fully clockwise to shut the valve.

Making the Fresh Gas Connections

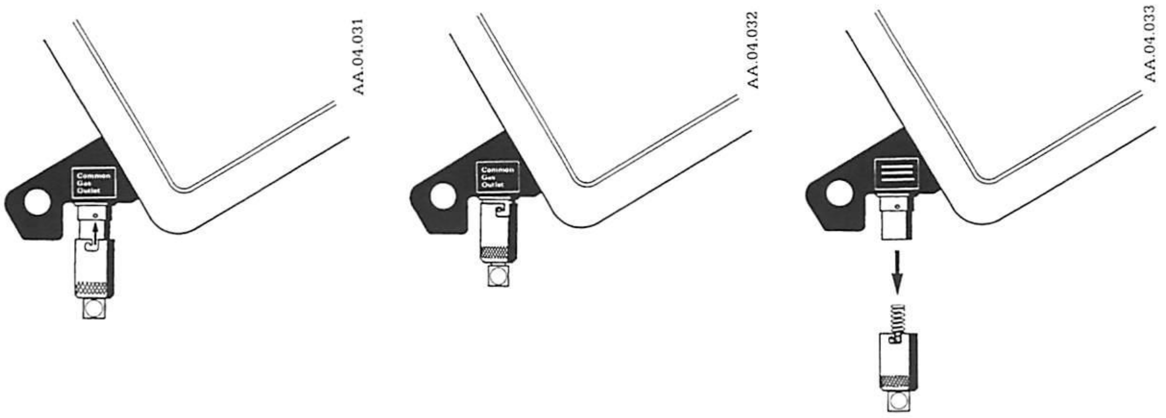
The anesthesia machine connects to the absorber with a spring-loaded common gas outlet adapter at one end of a fresh gas supply tube and an anti-disconnect fitting at the other end..

1. A spring-loaded connector is used to attach the fresh gas supply tube to the system's common gas outlet. Insert this gas-supply tube's inlet adapter into the common gas outlet. While you are holding the adapter near its front edge, push in and twist the it clockwise to lock it in place.

2. Connect the other end of the fresh gas supply tube to the anti-disconnect fitting labeled "Common Gas" on the absorber.

WARNING: Before using the anesthesia system: the inlet adapter must be placed completely onto the common gas outlet and then turned clockwise until it is secured by both protruding pins; the anti-disconnect nipple end must be placed securely into the absorber's common gas anti-disconnect fitting; and, to allow gas to flow to the breathing system, both ends of the outlet tubing assembly must be secured. Failure to correctly connect the breathing system may result in injury to the patient.

Figure 2-28
Attaching the inlet adapter to the common gas outlet

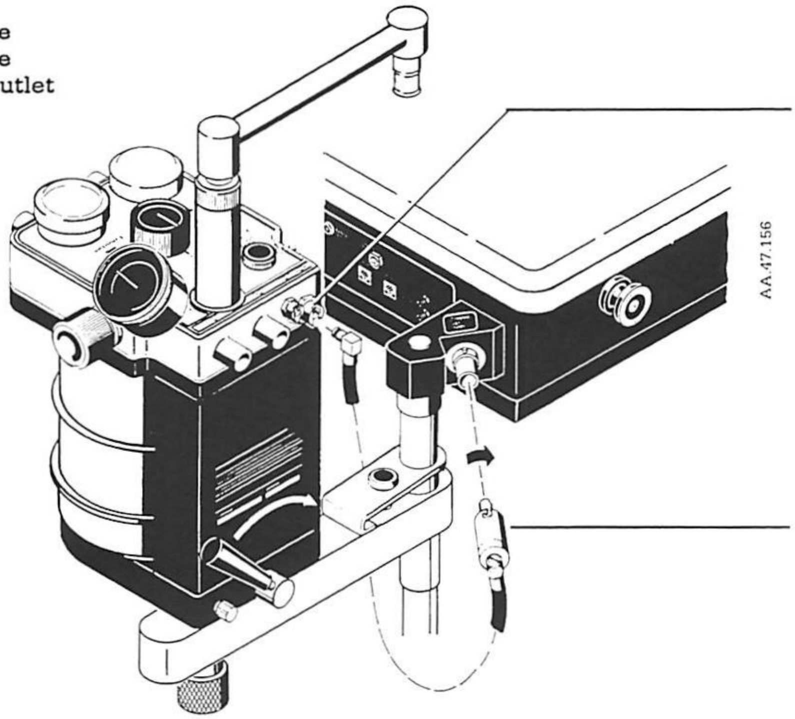


Place the inlet adapter all the way (up to the pins) onto the common gas outlet.

Turn the inlet adapter clockwise until completely secured by both (top and bottom) protruding pins.

If the inlet adapter is not secured, the spring ejects the adapter out of the common gas outlet, resulting in no gas flow to the patient circuit.

Figure 2-29
Connecting the absorber to the common gas outlet



Insert into port labeled "Common Gas"

Turn inlet adapter clockwise until secured

2.8 Setting the Altitude and Language

When to set the altitude parameter

Normally the altitude parameter needs to be set only when the system is first installed.

Adjusting the altitude parameter

1. Turn OFF the system's master switch power.
2. Make sure that the ventilator's mechanical ventilation switch is set to OFF.
3. Hold down the ventilator's inspiratory pause button, turn the master switch power back ON. Turn the flow knob to set the altitude (in meters)

```
FLOW KNOB TO SET
ALTITUDE: xxxx m
```

1 foot = 0.3048 meters

5. Press the Alarm Silence button 🔕 to display the language page. Turn the flow knob to select the language.

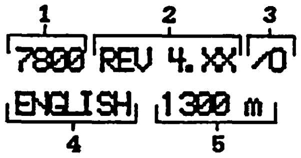
```
FLOW KNOB TO SET
ENGLISH
```

2.9 Setting the Reverse Flow Alarm, Sigh, Contrast, Audio Volume

Parameters set in the setup page are retained when the ventilator is turned OFF.

To set the altitude compensation

1. Move the mechanical ventilation switch to OFF.
2. Turn the system ON/OFF switch to ON.
3. Press and continue to hold down the alarm silence button, 🔇, then press in the inspiratory pause button. Release both buttons. The ventilator displays:



```
7800 REV 4.XX /O
ENGLISH 1300 m
```

1 meter (3.28 feet)

1. Ventilator Model
2. Software Version
3. Ventilator Drive Gas (A=Air; O=O2; E=Error)
4. Language
5. Altitude

WARNING: Pay attention to the information on the setup page. If the model number or drive gas is incorrect, have a trained Ohmeda service representative service the ventilator.

To exit the setup pages at any step, repeatedly press 🔇, do not adjust a control for 30 seconds, or set the mechanical ventilation switch to ON. All previous changes will be saved in the ventilator memory.

4. Press 🔇. The ventilator displays:

```
FLOW KNOB TO SET
REV FLOW ALM ON (or) OFF
```

Turn the flow knob to switch the alarm selection ON or OFF. If the volume sensor is at the proximal end of the Y, select OFF to disable the alarm. If the volume sensor is at the expiratory port of the absorber, select ON to enable the alarm.

5. Press 🔇. The ventilator displays:

```
FLOW KNOB TO SET
SIGH ON (or) OFF
```

Turn the flow knob to switch sigh breaths ON or OFF. When sigh is ON, the ventilator delivers one and a half times the tidal volume (up to a maximum 1.5 L) once every 64 breaths.

6. Press 🔕. The ventilator displays:

```
FLOW KNOB TO SET
CONTRAST: xx
```

Turn the flow knob to adjust the ventilator display contrast (XX) from 1 (lowest contrast) to 10 (highest).

7. Press 🔕. A tone sounds and the ventilator displays:

```
FLOW KNOB TO SET
AUDIO VOLUME: xx
```

Turn the flow knob to adjust the ventilator alarm volume (XX) from 1 (lowest) to 10 (highest). Tone volume changes to the selected level.

8. Press 🔕. The ventilator beeps once and displays:

```
CHECK SETTINGS!
```

Notes:

3/General Information

3.1 System Overview

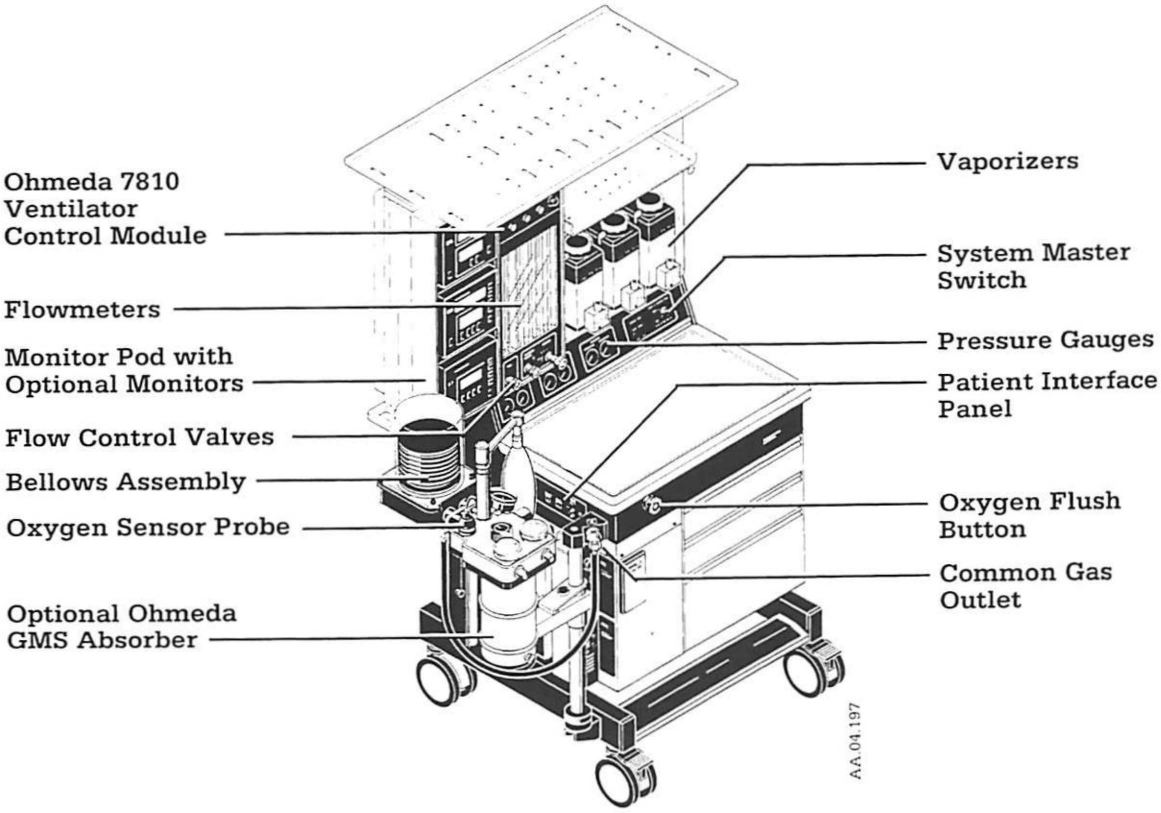
Gas machine with built-in Ventilator

The Ohmeda Modulus II Plus Anesthesia System includes the anesthesia gas machine with the built-in Ohmeda 7810 ventilator. Included in the anesthesia gas machine are flow control valves, flowmeters, pressure gauges, a master switch that controls the system's electrical and pneumatic power, a panel that displays the status of the electrical and pneumatic supplies and the built-in backup battery, an oxygen flush button, a waste-gas scavenging system, and a common gas outlet. Up to three vaporizers can be mounted on a vaporizer interlock manifold located at the right of the machine. To provide storage for additional monitors and accessories, two shelves and three drawers are provided. A tabletop serves both as a work surface and a handle for moving the machine. A lighting panel illuminates the work area. At the rear of the anesthesia machine are the gas pipeline connections, yokes for gas cylinders, and an electrical pod that includes a-c outlets.

Optional monitors

As many as three optional monitors, which can include the Ohmeda CO_2 Monitor, the Ohmeda Pulse Oximeter, the Ohmeda Non Invasive Blood Pressure Monitor, or a manual blood-pressure gauge, may be contained in the monitor pod at the left of the machine.

Figure 3-1
Ohmeda Modulus II Plus Anesthesia System, front view


Ohmeda 7810 Ventilator Control Module
Flowmeters
Monitor Pod with Optional Monitors
Flow Control Valves
Bellows Assembly
Oxygen Sensor Probe
Optional Ohmeda GMS Absorber
Vaporizers
System Master Switch
Pressure Gauges
Patient Interface Panel
Oxygen Flush Button
Common Gas Outlet
AA.04.197

Monitor sensor connection

A patient interface panel on the machine's left side provides a central location for connecting the sensors for the ventilator's built-in oxygen- and volume-monitoring circuits and for other optional monitors. From this panel, the cables are routed through the gas machine's main-frame to the ventilator or optional monitors.

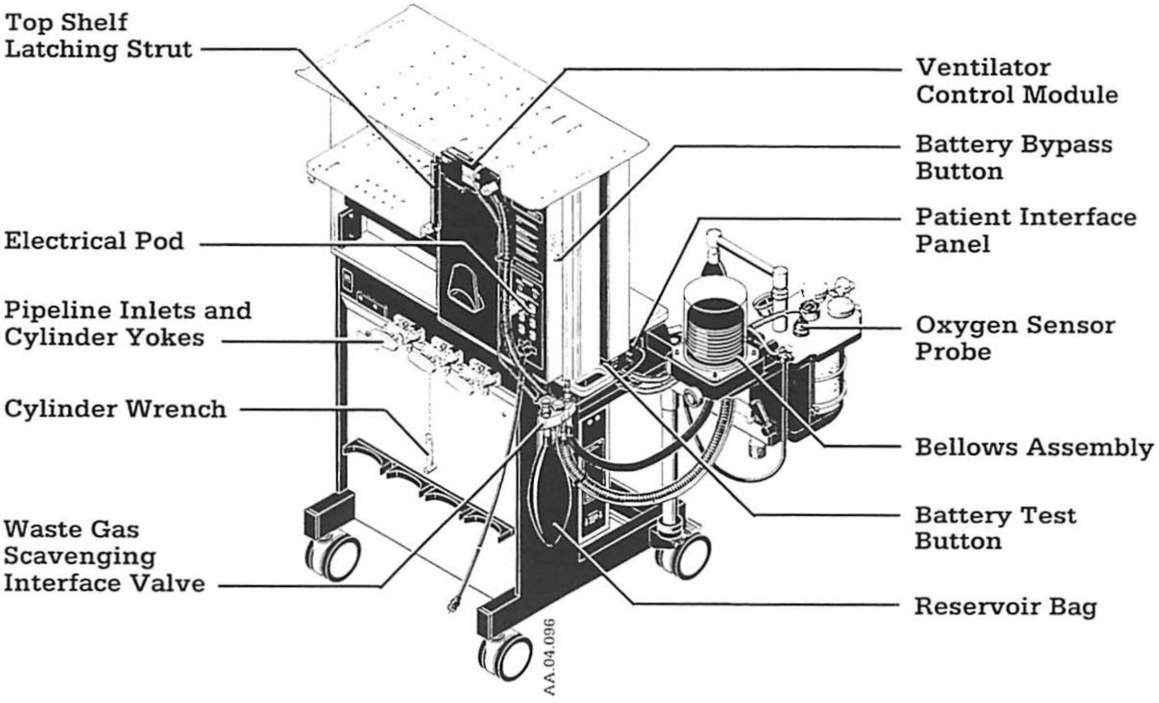
GMS Absorber

Although no absorber is included in the system, the Ohmeda GMS Absorber is highly recommended; the ventilator's bellows assembly can—through an interface manifold—be mounted securely to this absorber without using additional hoses. The oxygen and pressure-sensing devices are designed to easily connect to the Ohmeda GMS Absorber.

Ohmeda ventilator

The Ohmeda 7810 ventilator consists of two basic units: the control module and the bellows assembly. The ventilator's control module is mounted above the flowmeters at the upper-left of the anesthesia machine and serves three functions: it controls mechanical ventilation; it contains the ventilator's integrated monitors, providing oxygen, airway pressure, and exhaled volume monitoring; and it provides the ventilator's alarm system. The bellows assembly can either be mounted to an Ohmeda GMS Absorber on the anesthesia machine's absorber arm, or be remotely located on the machine's left side. In either case, a tube carries drive gas between the ventilator's control module to the bellows assembly.

Figure 3-2
Ohmeda Modulus II Plus Anesthesia System, rear view


Top Shelf Latching Strut
Ventilator Control Module
Battery Bypass Button
Electrical Pod
Patient Interface Panel
Pipeline Inlets and Cylinder Yokes
Oxygen Sensor Probe
Cylinder Wrench
Bellows Assembly
Battery Test Button
Waste Gas Scavenging Interface Valve
Reservoir Bag
AA.04.096

Waste Gas Scavenging Interface Valve

The Ohmeda Waste Gas Scavenging Interface Valve Assembly provides a central manifold for channeling waste gas from the breathing system to a waste gas disposal system. This assembly is usually mounted on the anesthesia machine's left side, but it can also be mounted on the absorber arm.

Ohmeda Modulus II Plus four-gas anesthesia system

Ohmeda also manufactures a four-gas anesthesia system in nearly the same configuration as the three-gas system covered in this manual. If your system is a four-gas unit, see Appendix I covering the differences between four-gas and three-gas units. Please note that the four-gas system is not an upgrade of the existing three-gas systems—it must be ordered direct from the factory.

3.2 Controls, Connectors, Devices, and Screen

Anesthesia Machine

The Ohmeda Modulus II Plus Anesthesia System encompasses pneumatic circuitry for mixing medical gases and agent vapor; a built-in ventilator, which provides oxygen, airway pressure, and exhaled volume monitoring; and a ventilator bellows assembly. The system accommodates additional, optional modules that provide oxygen saturation, carbon dioxide, and non-invasive blood pressure monitoring. An extensive alarm system provides off-normal (operator set or built-in) alarm indications for both the anesthesia machine and the ventilator. Switching ON the Ohmeda Modulus II Plus Anesthesia System's power automatically enables the system's monitors and alarm system.

Three gas supplies may be regulated and metered

The anesthesia machine's pneumatic circuitry can regulate and meter as many as three gas supplies. Circuitry for two gases, oxygen and nitrous oxide, is provided with all systems. Circuitry for an optional third gas, either air, heliox, or carbon dioxide, may be included as original equipment or installed later by trained service personnel.

Anesthesia Machine's Basic Framework

Rigid-steel lower framework

All of the system's components and modules are mounted on the anesthesia machine's rigid-steel lower framework—the main-frame. Four 12.7-cm (five-inch), hard-rubber wheels allow the stand to be easily moved. Locking brakes on the front wheels keep the stand stationary. On the machine's lower-right side is a three drawer cabinet that houses one 20.3-cm (eight-inch) and two 10.1-cm (four-inch), sliding drawers, all of which are 35.3 cm (14 inches) deep.

Much of the system's pneumatic and electronic circuitry is contained within the frame and concealed under a 35.5-cm by 60.9-cm (14-inch by 24-inch), formed stainless-steel table top. An extension of the table top's front edge serves as a handle for positioning the system.

Mounted on the upper-back of the main-frame is an aluminum framework that supports a monitor pod, an electrical pod, a flow control assembly, a vaporizer manifold, and the ventilator's control module.

Patient interface

Connections for the monitors and other patient circuit connections are located primarily on the left side of the gas machine.

Gas supply connections

The gas supply connections—cylinder yokes and pipeline inlets—are located at the stand's back plate.

Absorber arm

An adjustable-height bar on the stand's left side supports the absorber.

Additional monitor and equipment mounting systems

To accommodate additional monitors and other equipment, the Ohmeda Modulus II Plus Anesthesia System offers both vertical mounting tracks and two horizontal shelves. The system's top shelf is a long, deep shelf, whose angle can be adjusted. The other, middle shelf is smaller and fixed in a level position. Clips and straps are used to secure equipment to these shelves. Sliding brackets are used to attach equipment to the vertical mounting tracks on the system's upright supports.

⚠

WARNING: Remove all accessory equipment from the shelves before moving the anesthesia machine over bumps or on any inclined surface. Heavy top loading can cause the machine to tip over causing injury to the person moving it or to others.

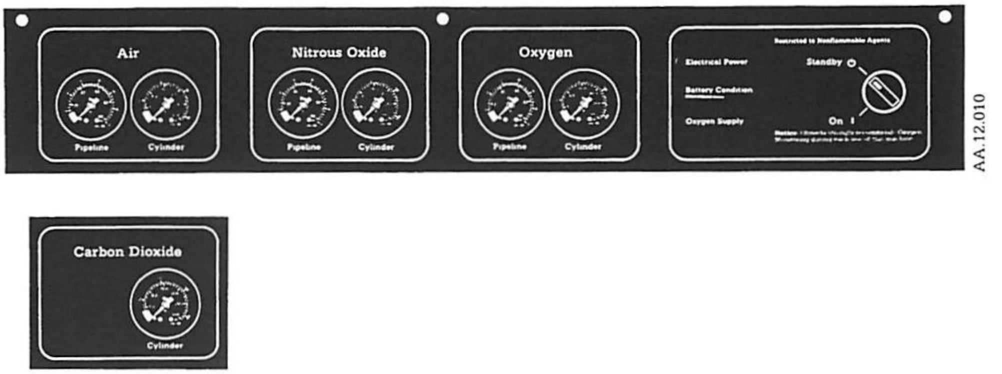
CAUTION: Do not place materials weighing more than 11.3 kg (25 lb.) on the lower, stationary shelf, or more than 27.2 kg (60 lb.) on the upper, tilting shelf. Over-loading may damage the shelves or cause instability.

3.3 Cylinder Yokes and Pipeline Connections

Pressure Gauge Window Panel

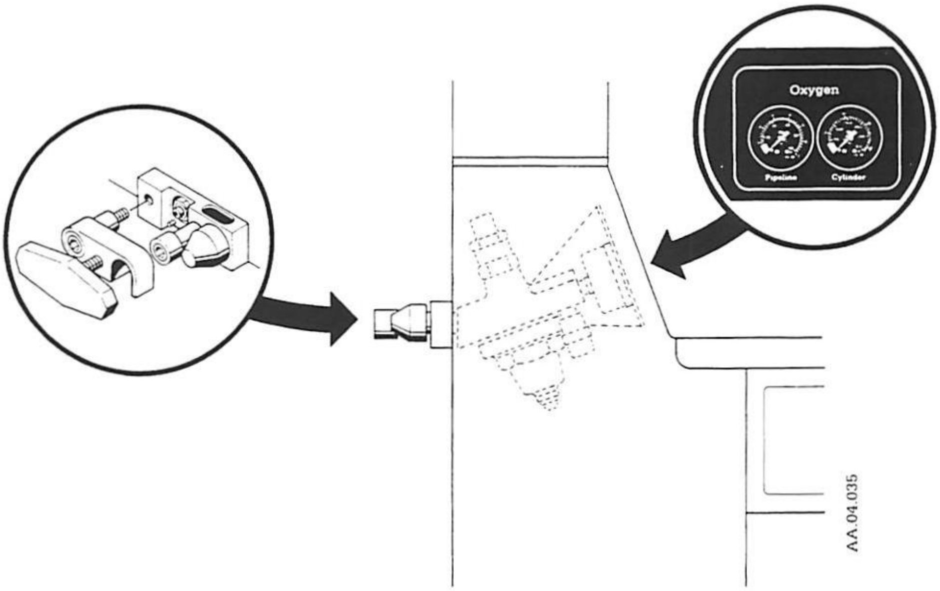
Analog gauges for the pipeline pressure and cylinder pressure of the oxygen, nitrous oxide, and—when installed—a third gas are mounted on the anesthesia machine's stand, behind the table top and next to the system master switch.

Figure 3-3
Pressure gauge window panel


Air
Pipeline
Cylinder
Nitrous Oxide
Pipeline
Cylinder
Oxygen
Pipeline
Cylinder
Restricted to Nonflammable Agents
Electrical Power
Battery Condition
Oxygen Supply
Standby
On
AA.12.010
Carbon Dioxide
Cylinder

The gauges for each gas are paired in the windows, with oxygen to your right; nitrous oxide in the center; and third gas on your left. In the pairs of gauges, cylinder pressure is shown on the right gauge; pipeline pressure is shown on the left gauge. All of these gauges are connected to gas supply modules which extend through the main-frame to the pipeline inlets and cylinder yokes. The gauges are mounted in the same order as the flowmeters and flow control valves, all of which are just above the gauges.

Figure 3-4
Pressure gauges
and regulators



Flow Control Valves

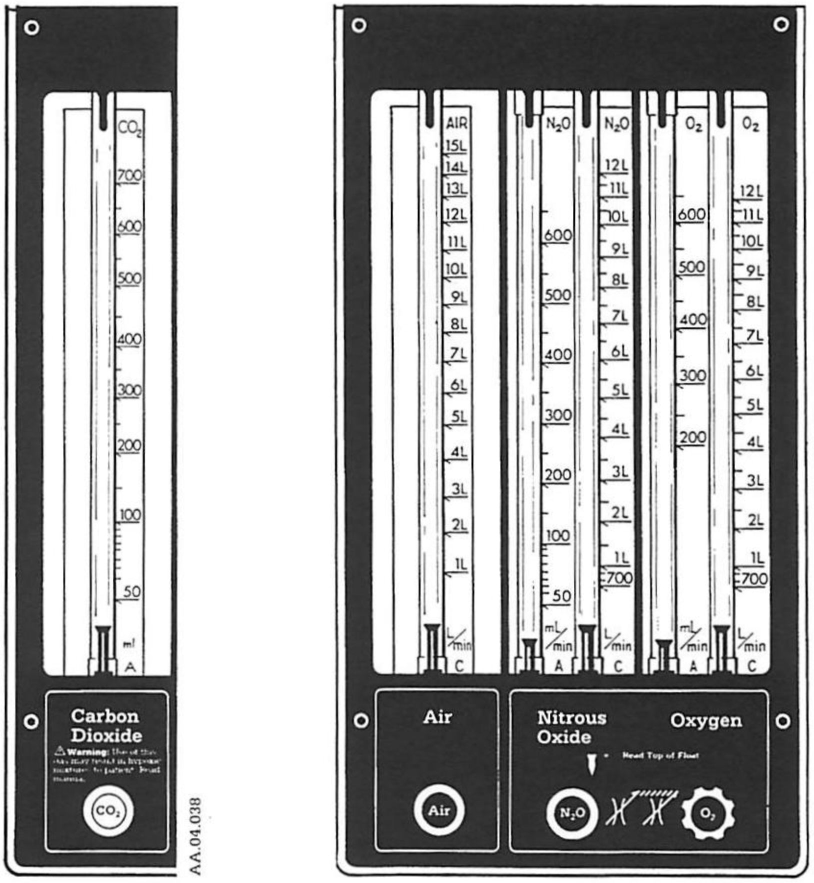
Each gas supplied to your anesthesia machine is controlled by a single flow control valve. These flow control valves, above the pressure gauges and below the flowmeters, are marked with the symbol for the gas they control and are color coded to match the backgrounds of the corresponding pressure gauges and flowmeters. So you can identify it by touch, the knob for oxygen is fluted. The knobs for nitrous oxide and, when included, a third gas are etched with a finer, cross-hatch pattern.

Proportion Limiting
Control System

The Ohmeda Link 25 Proportion Limiting Control System connects the oxygen and nitrous oxide flow control valves. This system helps ensure that any oxygen/nitrous-oxide mixture includes a minimum of about 25 percent oxygen and helps prevent the oxygen flow from dropping below 200 milliliters per minute (or 50 milliliters per minute when the low-flow option is installed).

WARNING: The Ohmeda Link 25 Proportion Limiting Control System ensures only that oxygen/nitrous-oxide mixtures will have a minimum (nominal 25 percent) oxygen concentration. HYPOXIC MIXTURES MAY BE DELIVERED IF GASES OTHER THAN OXYGEN, NITROUS OXIDE AND/OR AIR ARE USED, OR WHEN OPERATING AT LOW OXYGEN FLOW RATES. When using carbon dioxide as an additional gas, make sure the proportions of all gases are carefully adjusted in accordance with accepted clinical practice. Gas mixtures within the breathing system must be monitored when using these gases.

Figure 3-5
Flowmeters and flow control valves


CO₂
700
600
500
400
300
200
100
50
ml
A
Carbon Dioxide
CO₂
AA.04.038
AIR
15L
14L
13L
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
L/min
C
N₂O
600
500
400
300
200
100
50
mL/min
A
N₂O
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
700
L/min
C
O₂
600
500
400
300
200
mL/min
A
O₂
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
700
L/min
C
Air
Air
Nitrous Oxide
Oxygen
Read Top of Float
N₂O
O₂
AA.04.084

Flowmeters

Flowmeters for each gas included in your system are mounted directly above the corresponding flow control valve. The backgrounds at the tops and bottoms of these flowmeters are color coded to match the pressure gauges and control valves. When you are reading a flowmeter, sight across the top of the meter's float, inside the flowmeter's tube, to the scale on the immediate right of the float.

Flowmeter back-lighting

Back-lighting the flowmeters further enhances the visibility of flow measurement scales in low light levels. The adjustable intensity control allows you to select a light intensity best suited for the background light of the room. Each flowmeter has a light source, however intensity adjustment is common to all. If your machine does not have back-lighting, it is available as an option.

Flowmeters are factory calibrated

Both the oxygen and nitrous oxide flowmeters use pairs of tubes that are connected in series. The left-most tube in each pair is used for flows less than 700 milliliters per minute; the right-most tube indicates flows from 700 milliliters per minute to 12 liters per minute. For example, if oxygen is set to 500 milliliters per minute, the top of the float in the left tube lines up with 500. If the flow is increased to 2.5 liters per minute, the top of the float in the right tube lines up with the mark between "2L" and "3L". Unlike the oxygen and nitrous oxide flowmeters, the third-gas flowmeter uses a single tube. The flowmeters are factory calibrated to be accurate to ±2.5 percent at flow rates above 100 milliliters per minute and ±5 percent at flow rates below 100 milliliters per minute. A transparent shield helps to protect the flowmeter modules.

Cylinder Yokes And Pipeline Inlets

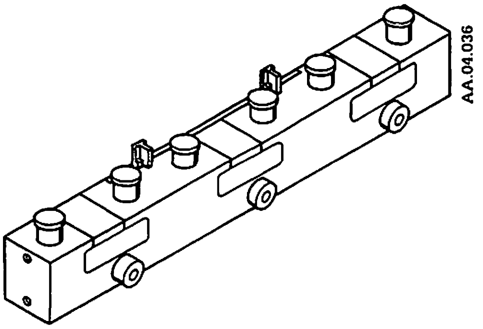
Pipeline gases connect to the inlets on the machine's rear panel and can be backed up by either "D" or "E" size reserve gas cylinders, secured by the yokes on the back of the anesthesia machine. During normal operation, when your hospital's pipelines are supplying gas, keep the cylinder valves closed. If a pipeline supply fails, use the included wrench to open the appropriate back-up cylinder.

Vaporizer Manifold And Interlock

WARNING: Simultaneous delivery of vaporized liquid anesthesia agent is possible when using vaporizers without interlocks. Use only one vaporizer at a time.

The vaporizer manifold, located next to the flowmeters, can hold up to three Ohmeda Vaporizers. Mechanisms in the vaporizers and manifold combine to form an interlock system — locking vaporizers into the gas circuit, allowing no more than one vaporizer to be switched ON at a time, allowing gas flow to enter only the single vaporizer that is switched on, and minimizing unwanted anesthetic trace vapor after the vaporizer is switched off.

Figure 3-6
Vaporizer manifold



The total flow from the gas distribution manifold, which is inside the machine, first enters the vaporizer manifold and then moves through only the vaporizer that is switched ON. Here it picks up the preset concentration of anesthetic vapor. This gas mixture then flows out of the vaporizer manifold to the common gas outlet.

Secondary Pressure Regulators

Both the oxygen and nitrous-oxide supply lines are equipped with secondary pressure regulators that level out pipeline surges and minimize bobbing of the flowmeter floats caused by pressure fluctuations in the supply lines.

Gas Distribution Manifold

Gas, after first being introduced to the machine through the pipeline inlets or the cylinders, passes through a set of secondary circuits to the gas distribution manifold. It then passes through the flowmeters, before it is combined with the total anesthetic gas mixture. The gas distribution manifold is the juncture of the second-stage circuitry and the flow control components.

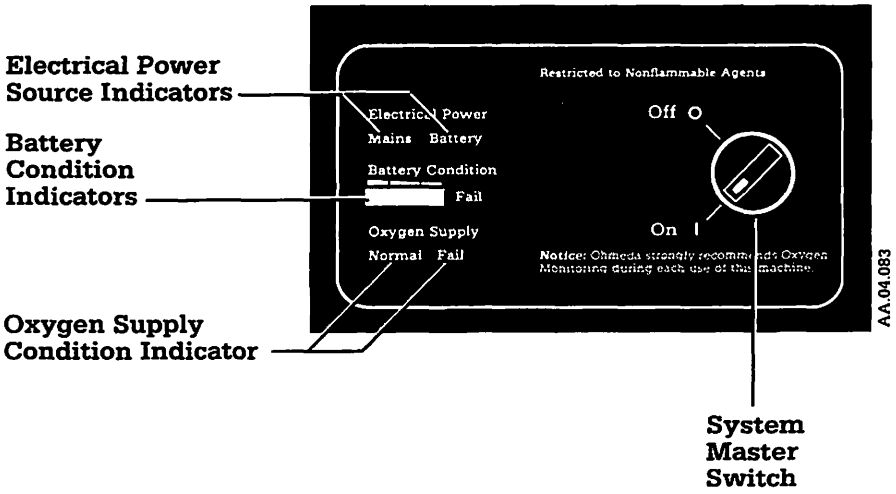
System Master Switch

A two-position master switch, located to the right of the pressure gauges, controls electrical and pneumatic power to the system. When the switch is in its upper position, both electrical and pneumatic power are off. In the lower position, both electrical and pneumatic power are ON.

Indicator Panel

Just left of the switch is the system's indicator panel, which provides the status of the system's electrical supply, battery condition, and oxygen supply.

Figure 3-7
System master switch


Electrical Power Source Indicators
Battery Condition Indicators
Oxygen Supply Condition Indicator
Restricted to Nonflammable Agents
Electrical Power
Mains
Battery
Battery Condition
Fail
Oxygen Supply
Normal
Fail
Off O
On I
Notice: Ohmeda strongly recommends Oxygen Monitoring during each use of this machine.
AA.04.083
System Master Switch

When the switch is set to OFF: the panel's indicator lights are off; gas is not supplied to the flow control circuits; electrical power is not supplied to the monitors or ventilator; but a-c power is provided to the a-c outlets on the back of the anesthesia machine.

When the switch is set to ON: the green "Normal" and "Mains" indicators are lighted; gas is supplied to the machine's circuits; and electrical power is provided to the monitors and the ventilator.

If the switch is set to ON and the anesthesia machine's d-c power supply fails, either because of an electronic failure or because the anesthesia system's a-c power is lost, the "Mains" indicator will go out and the red "Battery" indicator will flash. When the "Battery" indicator is on, the system is running on its built-in backup battery designed to temporarily provide power to allow the ventilator and its integrated oxygen, volume, and airway pressure monitors to continue operating.

Beneath the electrical power indicators are the battery-condition indicators. Whenever the battery is powering the system, either a colored bar or "Fail" will be lighted to indicate the backup battery's condition. See "Backup Battery" and "Battery Bypass" for further battery details.

Oxygen Supply Monitoring

The system also monitors the condition of the oxygen supply. When the oxygen supply pressure is 34 psig (235 kPa) or greater, the "Normal" indicator is lighted. But if the oxygen supply pressure drops below 28 psig (193 kPa), the system lights the "Fail" indicator and sounds the oxygen supply alarm continuously.

Pneumatically operated shutoff valves

The pressure sensor shut off valves are pneumatically operated valves that shut off N_2O and optional gas flow—if the oxygen supply pressure falls to about 20 psig (138 kPa).

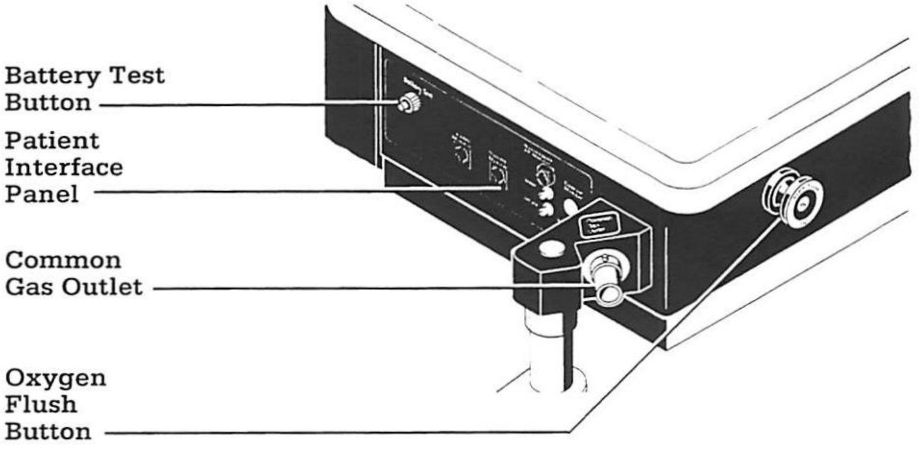


Figure 3-8
Oxygen flush button and common gas outlet

Oxygen Flush Button

Pushing the oxygen flush button opens a valve that supplies 45-75 liters per minute of oxygen to the common gas outlet. To minimize the chance of accidental engagement, the button, which is on the panel under the table top's front edge, is recessed and self closing. Either the oxygen pipeline or cylinder can provide gas for the oxygen flush; the oxygen flush button is operational whenever an oxygen supply is connected to the oxygen gas supply module.

Common Gas Outlet

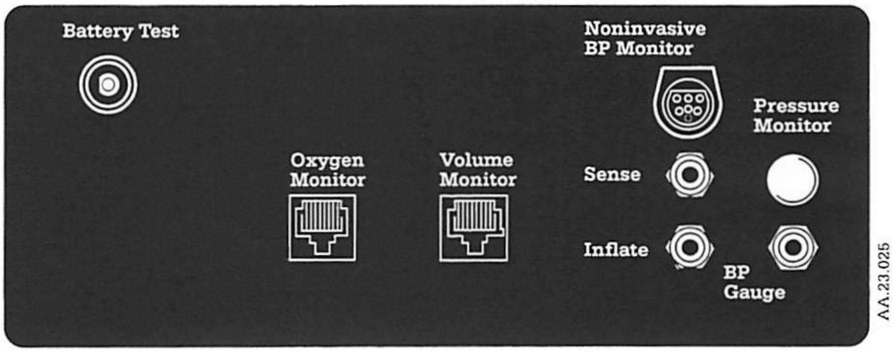
Mixed Gas into the Patient Circuit

At the common gas outlet the system delivers the combined outputs of the vaporizers, the gas flowmeter modules, and, when enabled, the oxygen flush. The common gas outlet is located on the upper absorber post assembly bracket, next to the patient interface panel. A latching bayonet connection helps prevent accidental disconnections and helps provide a secure, leak-tight connection.

Patient Interface Panel

Both the ventilator's oxygen- and volume-monitoring circuits use external sensors that must connect to the ventilator's control module. The patient interface panel, on the stand's left side, under the work surface, provides a central connection location for these sensors and sensors for certain other optional monitors. From the panel, the cables are routed through the gas machine's frame to the ventilator or optional monitors. The connectors are labeled and keyed to help prevent misconnections; and blank plugs are installed in place of connectors for optional monitors that are not included in your system. The battery test button is also on the patient interface panel.

Figure 3-9
Patient interface panel



Backup Battery

The Battery Test Button

Pressing the battery test button momentarily connects the system's built-in backup battery to the battery-condition meter on the master switch panel. Before each case, while the system's a-c power is switched on, press the battery test button to test the system's backup battery.

When you press the battery test button, either a colored bar or "Fail" is lighted to indicate the backup battery's condition, unless the battery is completely discharged. When the battery is fully charged, the left-most green-indicator bar is lighted. As the battery becomes progressively weaker, the lit bar moves from green, to yellow, and then to red. When the battery is almost completely discharged, the system flashes the

"Fail" indicator. If the battery is completely discharged, the system switches itself off. Do not start to use the system unless the battery is completely charged. If the battery fails during an a-c power outage, you can use the battery bypass button to restart the system when a-c power is restored.

If the anesthesia machine's d-c power supply fails, either because of an electronic failure or because the anesthesia system's a-c power is lost the system's built-in backup battery provides backup power to the ventilator and its integrated oxygen, volume, and airway pressure monitors. If the ventilator is in the mechanical ventilation mode, the battery—when fully charged as shown on the battery condition indicator—typically powers mechanical ventilation and monitoring for about one hour and, for an additional half hour, provides monitoring only. Once the battery is almost completely discharged—as shown when the battery condition "Fail" indicator is flashing—the system must be plugged in and switched ON for about 24 hours to recharge the battery.

Using only the backup battery to run the anesthesia system eventually drains the battery completely. When the battery is completely discharged, none of the panel indicator lights work and the system's electrical devices will not function. However, the gas delivery system of the machine does remain operational.

DO NOT begin a case unless the system's backup battery is fully charged prior to starting. If a-c power failure should occur during a case, the system goes into a battery backup operational mode. If a-c power is restored, you can restart the system using the battery bypass button. The battery bypass button is a means of returning the system to normal a-c operation when a-c power is restored after a failure. However, Ohmeda recommends that the battery bypass button be used to restart the system ONLY when in the backup battery operation mode and normal power is restored during a case.

Battery Bypass

The Battery Bypass Button

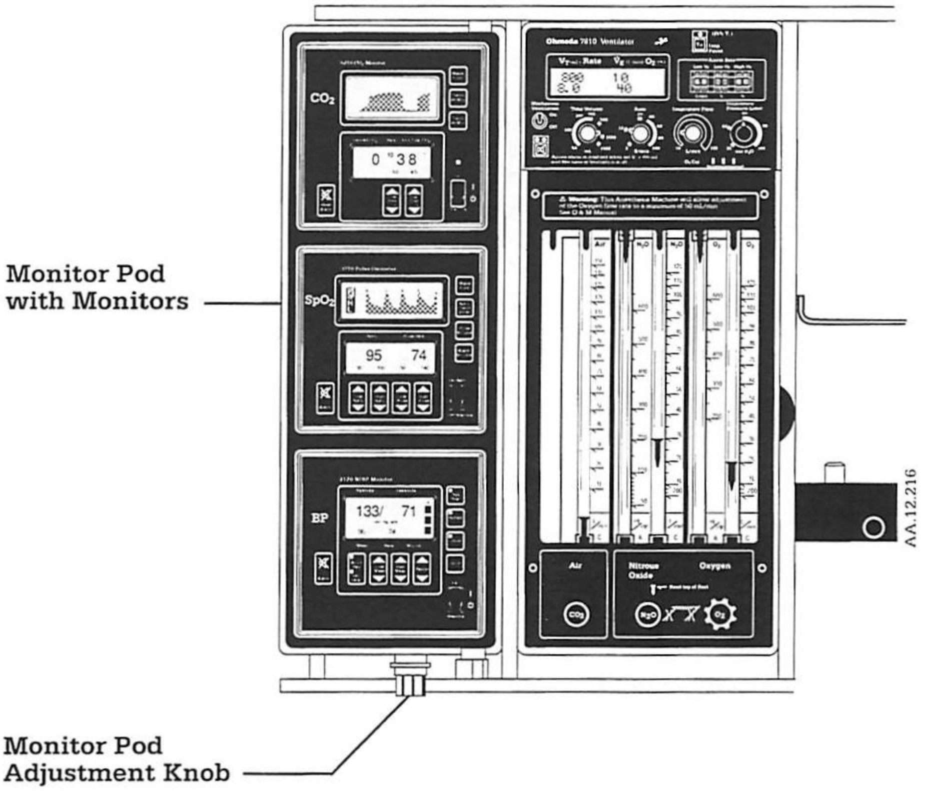
Located on the side of the electrical pod, the battery bypass button lets you restart the system if the backup battery fails during an a-c power outage. Press this button to restart the system only if a-c power is restored. Do not begin a case unless the backup battery is completely charged.

Monitor Pod And Optional Monitors

Monitor pod

A monitor pod that allows up to three optional Ohmeda monitors is mounted to the left of the flow control assembly. This pod, which pivots and can be locked into position, accommodates up to three of these devices: the Ohmeda CO_2 Monitor, the Ohmeda Pulse Oximeter, the Ohmeda Non Invasive Blood Pressure Monitor, or the manual blood-pressure gauge. If fewer than three optional monitors are included in your system, blank panels or optional pod bins are installed in the empty positions.

Figure 3-10
Monitor pod


Monitor Pod
with Monitors
Monitor Pod
Adjustment Knob
CO₂
SpO₂
BP
0 38
95 74
133/ 71
Ohmeda 7810 Ventilator
Air
Nitrous Oxide
Oxygen
AA.12.216

The monitors are divided into two pieces: a display module, mounted in the monitor pod; and an electronics module, mounted in the anesthesia machine's main-frame. The display module contains the monitor's screen and some or all of its controls, whereas the electronics module contains the monitor's measuring and processing circuits. Cables routed through the system framework connect the display modules, the electronics modules, system power, and patient connectors. Although the display modules can be easily removed from the monitor pod, they do not function outside the system. Only trained service personnel should install or remove electronics modules.

⚠ **CAUTION: All Ohmeda monitors, the vaporizers, and the Ohmeda GMS Absorber, have their own operation-and-maintenance manuals. Before using the system, read the manuals for all the installed devices.**

Optional Blood Pressure Gauge

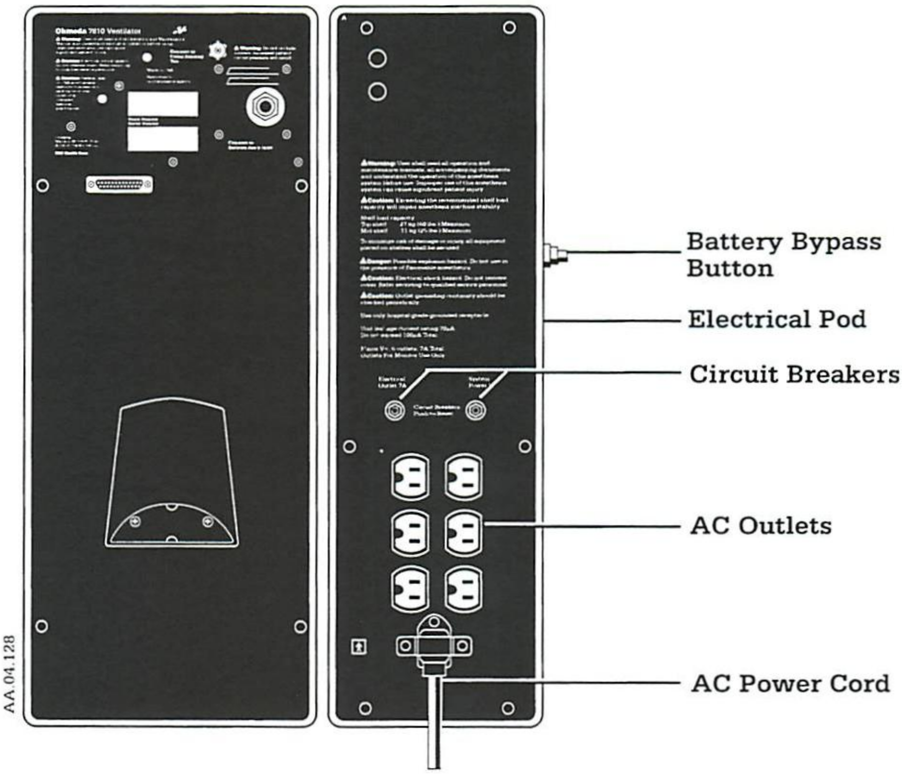
Manually-operated blood pressure gauge

A manually-operated, analog blood pressure gauge can be installed as an integral system component. When included with your system, this gauge is installed either in the monitor pod or in a "mini-pod" to the left of the monitor pod.

Electrical Pod

Located directly behind the monitor pod, the electrical pod houses the system's circuit breakers, auxiliary a-c power outlets, power cord and battery bypass button . The seven-ampere circuit breaker helps protect the machine's a-c outlets; the five ampere circuit breaker helps protect the machine's internal a-c power supply.

Figure 3-11
Electrical pod



CAUTION: Make the electrical connection at an appropriate hospital grade receptacle only.

WARNING Connecting equipment to the auxiliary a-c outlets may increase electrical hazards if a protective ground conductor is defective.

Lighting Panel

Two levels of illumination are provided by the lighting panel, mounted under the tilting shelf. A three-position switch controls the lighting panel. This switch is active when the machine's electrical circuits are switched on, but the lighting panel does not function when the system is powered by its backup battery.

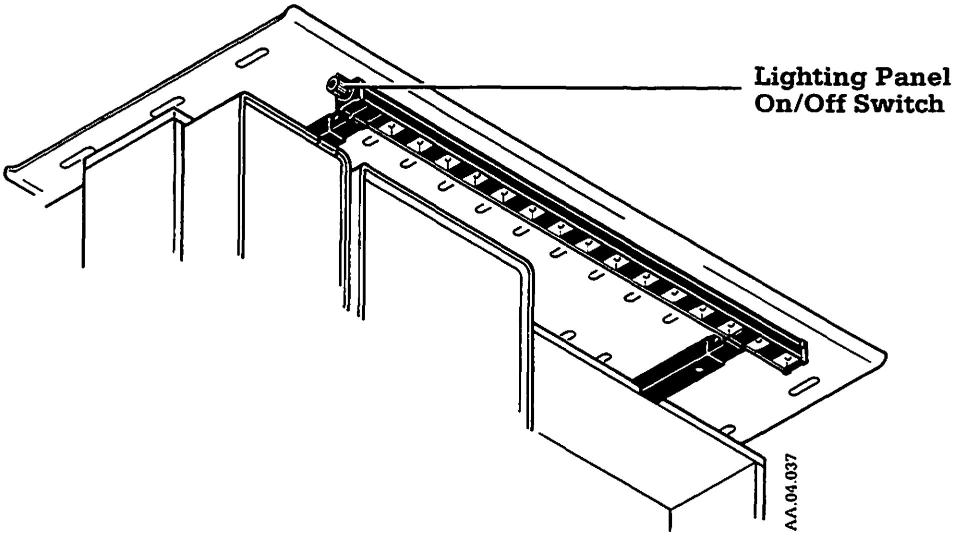

Lighting Panel On/Off Switch
AA.04.037

Figure 3-12
Lighting panel

Waste Gas Scavenging Interface Valve Assembly

The Ohmeda waste gas scavenging interface valve assembly provides a central manifold for channeling waste gas from the breathing system to a waste-gas disposal system. The valve assembly consists of three 19-mm male connectors, an adjustable needle valve and a pair of gravity-loaded relief valves. The 19-mm connectors accommodate tubing and a reservoir bag. The relief valves limit positive and negative pressures, while the needle valve controls the suction applied to the manifold.

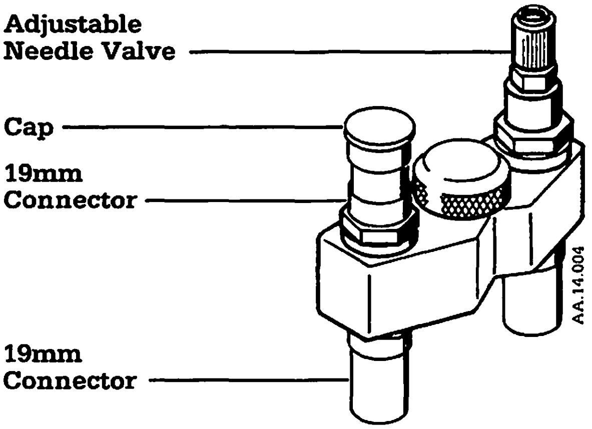

Adjustable Needle Valve
Cap
19mm Connector
19mm Connector
AA.14.004

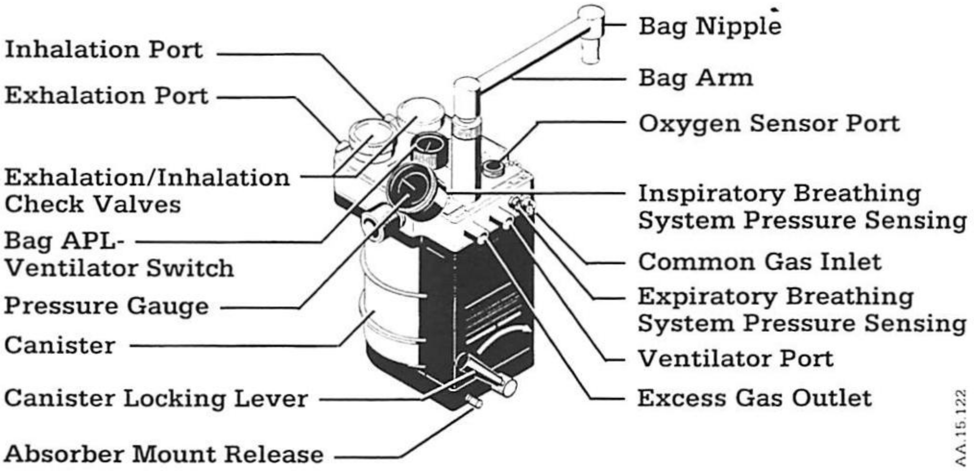
Figure 3-13
Waste gas scavenging interface valve assembly

You can mount this assembly in either of two locations: the left side of the anesthesia machine; or, if necessary, the absorber swivel arm. (See section 2.)

Absorber

The Ohmeda GMS (Gas Management System) Absorber is the Ohmeda Modulus II Plus Anesthesia System's companion unit and its use, because of compatibility with other system components, is highly recommended. The absorber mounts on the absorber post assembly located at the left front corner of the system. For more information, see the Ohmeda GMS Absorber Operation and Maintenance Manual.

Figure 3-14
Ohmeda GMS Absorber


Inhalation Port
Exhalation Port
Exhalation/Inhalation Check Valves
Bag APL- Ventilator Switch
Pressure Gauge
Canister
Canister Locking Lever
Absorber Mount Release
Bag Nipple
Bag Arm
Oxygen Sensor Port
Inspiratory Breathing System Pressure Sensing
Common Gas Inlet
Expiratory Breathing System Pressure Sensing
Ventilator Port
Excess Gas Outlet
AA.15.122

Ventilator

Two basic units the control module; and the bellows assembly

The Ohmeda 7810 Ventilator consists of two basic units: the bellows assembly, which contains the bellows and bellows housing, and the control module, which contains the ventilator's control valves, processing circuits, controls, and display screen.

Figure 3-15
Ventilator's control module

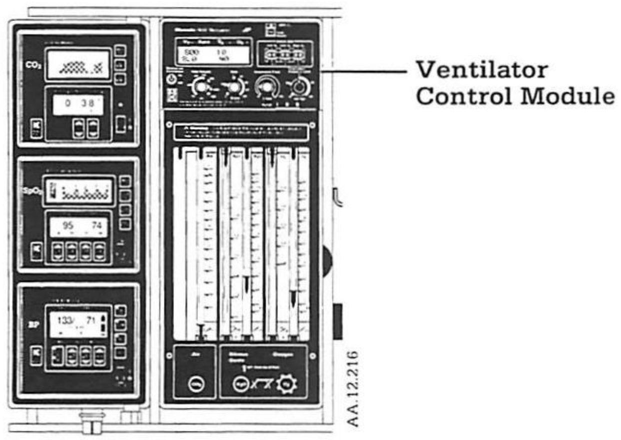
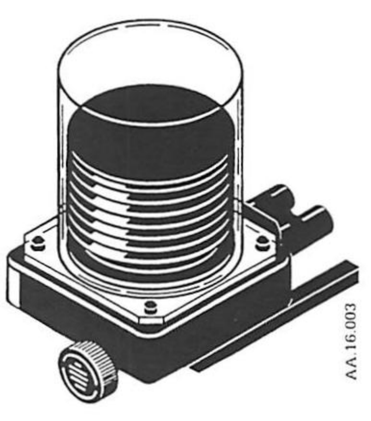

Ventilator Control Module
AA.12.216

Figure 3-16
Ventilator's bellows assembly



Control Module

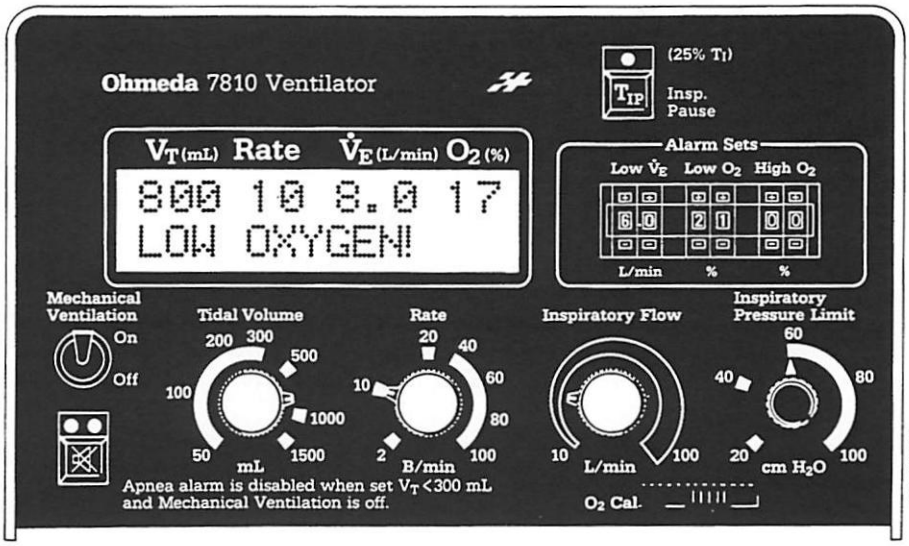
The control module serves three functions: it controls mechanical ventilation; it contains the ventilator's integrated monitors, which provide oxygen, airway-pressure, and exhaled-volume monitoring; and it supplies the ventilator's alarm system. By using the control module's front panel knobs, pushwheels, and display, you can set and view the ventilator's operating parameters and alarm limits, view output from the integrated monitors, and initiate mechanical ventilation. Switching ON the Ohmeda Modulus II Plus Anesthesia System's power enables the ventilator's monitors and alarm system, even if the mechanical ventilation switch is OFF.

Control Module Front Panel

Display screen

The ventilator's Liquid Crystal Display screen serves three functions: on its top line it provides numeric readouts for expired tidal volume, breath rate, expired minute volume and inspired oxygen concentration; on its bottom line it displays messages such as alarms and control settings. For certain functions, such as the setup page, the ventilator will display instructions on both lines of the screen.

Figure 3-17
Ventilator control module's front panel


Ohmeda 7810 Ventilator
(25% T_I)
T_{IP}
Insp. Pause
V_T (mL) Rate $\dot{V}_E$ (L/min) O_2 (%)
800 10 8.0 17
LOW OXYGEN!
Alarm Sets
Low $\dot{V}_E$ Low O_2 High O_2
6 0 2 1 0 0
L/min % %
Mechanical Ventilation
On
Off
Tidal Volume
50 100 200 300 500 1000 1500
mL
Rate
2 10 20 40 60 80 100
B/min
Inspiratory Flow
10 L/min 100
Inspiratory Pressure Limit
20 40 60 80 100
cm H_2O
Apnea alarm is disabled when set V_T <300 mL and Mechanical Ventilation is off.
O_2 Cal.
AA.18.047

Tidal volume dial

The tidal volume knob lets you set the tidal volume at levels from 50 mL to 1500 mL. As you turn the knob, the ventilator displays the tidal volume setting as well as the resulting I:E ratio. The resolution varies within four ranges, depending on the tidal volume knob's position. In the range from 50 mL to 100 mL, the tidal volume can be set in 2-mm increments. In the range from 100 mL to 250 mL, the tidal volume can be set in 5-milliliter increments. In the range of 250 mL to 1000 mL, the tidal volume can be set in 10-milliliter increments. And in the range of 1000 mL and up, the tidal volume resolution is 20-mL.

To check the tidal volume setting without changing its value, just touch the front of the knob; the ventilator will then display the current tidal volume setting and I:E ratio.

The I:E ratio is displayed as a reminder that changing the tidal volume alters the I:E ratio. If necessary, use the Inspiratory Flow Dial to maintain the desired I:E ratio.

Breath rate knob

Turning the rate knob changes the breath rate used for mechanical ventilation. The ventilator displays the rate as it changes as well as the resulting I:E ratio. The rate is adjustable from 2 breaths per minute to 100 breaths per minute in whole number increments. Touching the rate knob will display the current rate and I:E ratio setting on the screen.

The I:E ratio is displayed as a reminder that changing the breath rate alters the I:E ratio. If necessary, use the Inspiratory Flow knob to maintain the desired I:E ratio.

Inspiratory flow knob

The inspiratory flow knob lets you set the inspiratory flow rate, which is continuously variable from 10 liters per minute to 100 liters per minute in increments of 1. Whenever you adjust or just touch the inspiratory flow knob, the ventilator will display the current I:E ratio, which it calculates based on the set inspiratory flow, tidal volume, breath rate, and the inspiratory pause status. Because the inspiratory flow is continuously variable within its range, the ventilator's actual flow is continuously variable from 1:0.5 to 1:999. Rather than display I:E ratios in non-standard increments, such as 1:2.13 or 1:1.97, the ventilator displays the I:E ratio rounded to the nearest 0.5. For example, when the ventilator uses a ratio of 1:2.13, it displays 1:2. And when it uses 1:1.97, it displays 1:2.

Use the Inspiratory Flow knob to set the desired I:E ratio after the breath rate and tidal volume have been correctly set.

Inspiratory pressure limit knob

Both the maximum inspiratory pressure and sustained pressure alarm limits are set by the inspiratory pressure limit knob, which must be pushed in while turning to change the settings; the ventilator sets the sustained pressure limit to correspond to the inspiratory pressure limit knob setting. The maximum inspiratory pressure limit range is 20 to 100 cm H_2O with a resolution of 1 cm. For inspiratory pressure limits of 20 cm H_2O to 60 cm H_2O, the ventilator sets the sustained pressure limit to one half the inspiratory pressure limit. Any inspiratory pressure limit setting higher than 60 cm H_2O will result in a sustained pressure limit of 30 cm H_2O.

As you push and turn the inspiratory pressure limit knob, the ventilator will display both the maximum pressure limit and sustained pressure limit settings. However, unlike the other three control knobs, just touching this knob will not generate a display.

During mechanical ventilation, the maximum inspiratory pressure limit you set is used by the ventilator's electronically controlled, automatic, high pressure relief system to manage excessive airway pressure. If, while the mechanical ventilation switch is ON, the ventilator detects airway pressure higher than the limit you set, it will generate a high pressure alarm and terminate the inspiratory cycle.

The ventilator also displays a message if you set the inspired pressure limit to more than 60 cm H_2O. This message is displayed in the non-mechanical ventilation mode only; during mechanical ventilation, this message is not displayed.

Inspiratory pause button

Pressing the inspiratory pause button adds an inspiratory pause--an inflation hold--to the inspiratory cycle. When the inspiratory pause function is active, the ventilator adds an inspiratory pause equal to 25 percent of the set inspiratory time. The ventilator, to maintain the original breath rate, then decreases the expiratory time by the same amount that the inspiratory time is increased; pressing the inspiratory pause button alters the I:E ratio

After you press the inspiratory pause button, the ventilator displays the new I:E ratio and lights the green indicator on the button to indicate that the inspiratory pause function is active. To disable the inspiratory pause, press the button again; the ventilator will switch OFF the indicator light and display the I:E ratio, which is calculated from the other front-panel control settings.

You can continue to adjust the ventilator's front panel controls even when the inspiratory pause function is active. If, while the function is ON, you adjust a front panel control, the instrument takes the inspiratory pause formula into account when it calculates and displays a new I:E ratio.

Mechanical ventilation On/Off switch

The mechanical ventilation switch controls mechanical ventilation only. When the switch is OFF, the monitors still functions and the alarm system is still active, although certain alarms are enabled only during mechanical ventilation. When you want to start mechanical ventilation, move the switch to ON.

Always switch ON the ventilator using the anesthesia system's master switch, and set the ventilator's controls before switching ON mechanical ventilation.

Alarm set push-wheels

Use the three alarm-set pushwheels to change the low-minute-volume, low-oxygen and high-oxygen alarms' set points. To increase the value of an alarm set point, push the button directly over the digit you want to change. To decrease the value, push the button under the digit you are changing.

Anytime you change the value of an alarm set point, the ventilator will display, for a few seconds, that alarm's value. Although all of the digits can be set to zero, the ventilator will not accept certain oxygen alarm settings, and will generate warning messages for others.

The oxygen alarm limits are 18 percent to 99 percent in one percent increments. The low minute volume alarm limits are zero liters per minute to 9.9 liters per minute in 0.1 liters per minute increments.

Oxygen calibration thumbwheel

The oxygen calibration thumbwheel is used to calibrate the oxygen monitor's sensor. Use this thumbwheel during the oxygen monitor calibration procedure.

Alarm silence button

☒

To silence an audible alarm, press the alarm silence button. If that alarm condition continues, the alarm will sound again in 30 seconds. If, however, a new alarm condition occurs, its audible alarm will sound immediately. Certain alarms can be silenced permanently, even if the alarm conditions continue. These alarms include power failure, oxygen sensor failure, low battery, ventilator failure, oxygen calibration error, and volume sensor failure.

When the mechanical ventilation switch is OFF--when the ventilator is in its non-mechanical ventilation mode--pressing the alarm silence button cancels and resets the apnea and low minute volume alarms; the "VOL MON STANDBY" message will be displayed and the two alarms will not sound again even if the alarm conditions continue. However, if the ventilator senses another breath, the alarm timers and sensor circuits will again be activated and any alarm condition that occurs will trigger an appropriate alarm.

The alarm silence button--combined with the inspiratory pause button--also provides a way to enter and step through the setup page mode. To enter the setup page, move the mechanical ventilation switch to OFF, hold down the alarm silence button, then press the inspiratory pause button. Once the setup page is displayed, press the alarm silence button again to move from step to step.

Alarm indicator LEDs

The two light emitting diodes (LEDs) embedded in the alarm silence button indicate the status of alarms. When an alarm condition first occurs, a message will appear on the screen, a tone will sound, and an LED will flash. Once the alarm silence button is pressed, the ventilator will light the LED continuously to remind you that the alarm condition still exists. The red LED is lighted during alarm conditions that require immediate operator response. The yellow LED indicates alarm conditions that require prompt operator response or operator awareness.

Control Module Rear Panel

Drive gas output

The ventilator bellows' driving gas supply is delivered from the connector labeled "Connect to Bellows Ass'y Inlet."

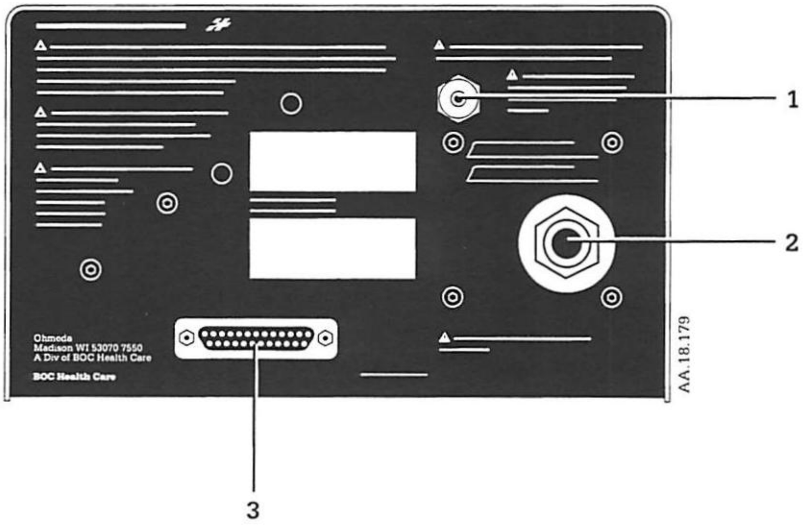
Pressure sensing input

For remote recording, a 25-pin female "D" type connector that is labeled "Ventilator Serial Interface" provides access to the ventilator's RS232C serial port, which conforms to the Ohmeda standard communications protocol (see the appendix).

WARNING: When specific DIP switches are set, writing to the ventilator's RS232 port can alter the operation of the ventilator's software, which may result in unpredictable performance. Do not alter the ventilator's hardware or software.

Figure 3-18
Ventilator control module's rear panel

1. Pressure sensing input
2. Drive gas output
3. Serial interface connector

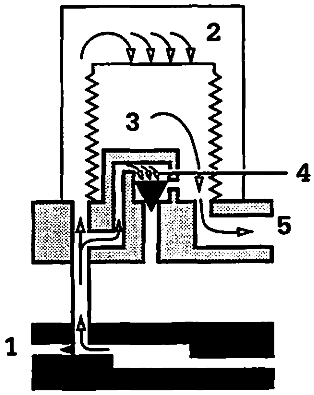


3.4 Theory Of Operation

The Ventilation Cycle

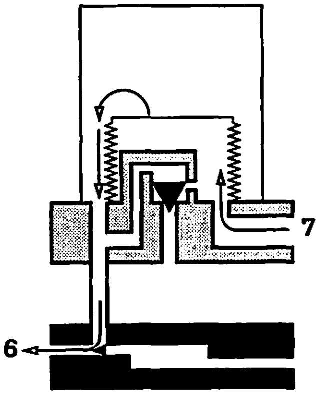
The bellows assembly is the interface between the control module's driving-gas circuit and the patient breathing system. During inspiration, driving gas from the control module compresses the bellows; during expiration, breathing system gas fills the bellows, forcing it to rise. As the ventilator cycles from inspiration to expiration, a set of valves controls the pressure in the two circuits.

Figure 3-19
Ventilation cycle



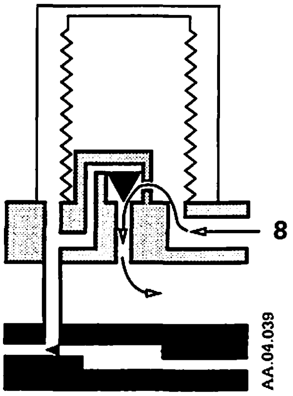
1. Exhalation valve
2. Driving gas
3. Patient circuit gas
4. Pressure relief valve
5. To patient circuit

Inspiration starts when the ventilator's control module closes the exhalation valve (1) and delivers driving-gas (2) to the bellows housing. As the driving-gas pressure increases, the pressure relief valve (4) closes and the bellows is compressed. This bellows compression forces gas out of the bellows, into the patient-circuit (5), breathing system, and into the patient's lungs. The control module computes the volume, rate, and timing of driving-gas needed, and delivers drive gas until it reaches the calculated gas volume; then flow stops. If the ventilator detects airway pressure higher than the limit you set using the inspiratory pressure limit control, the ventilator generates a high pressure alarm, opens the exhalation valve, and ends inspiration.



6. Driving gas
7. From patient circuit

At the start of expiration, the exhalation valve opens and the gas-flow direction in driving-gas (6) and the patient-circuit (7) breathing system reverses. Fresh gas from the anesthesia machine and exhaled gases from the breathing system enter the bellows' interior, forcing the bellows to expand; the extending bellows displaces the drive-gas (6), which is released to the atmosphere.



If the pressure inside the bellows exceeds ≈2.5 cm H_2O during the expiratory cycle (when the bellows has extended completely), the pressure relief valve opens and releases any excess breathing system gas (8)through the bellows assembly exhaust port.

8. Excess patient circuit gas

Volume Monitoring

Two volume measurements--tidal volume (V_T) and expired minute volume (V_E)--and the breath rate (Rate) are displayed on the ventilator's front panel. The ventilator measures all of these displayed values directly, based on the readings of a single volume sensor in the breathing system. Because of compliance losses and fresh gas gains in the breathing system, these measured and displayed values may be different than the values you set using the ventilator's front panel controls.

To measure the exhaled patient volume, the ventilator uses a volume sensor cartridge which contains a vane that is forced to rotate by gas traveling through the breathing system. A clip-on, optically coupled sensor translates the direction and speed of the vane's rotation into electrical pulses for the ventilator's microprocessor to analyze. The sensor clip also contains a heater, which is used to help prevent condensation in the transducer cartridge. Anytime the control module is ON, the heater is ON.

Airway Pressure Monitoring

The Ohmeda 7810 Ventilator continuously monitors airway pressures in the patient breathing system, and then uses this information to generate alarms and manage airway pressure. This airway pressure monitoring information is used only internally by the ventilator; the ventilator does not display this information.

The ventilator's airway pressure monitoring uses a transducer located inside the ventilator control module. A flexible tube fastened to a sensing port in the breathing system connects to this transducer in the control module.

Oxygen Monitoring

The Ohmeda 7810 Ventilator uses a galvanic fuel cell to measure the concentration of inspired oxygen. In addition to displaying the oxygen concentration, the ventilator uses this information to generate high-oxygen and low-oxygen alarms based on the levels set using the front panel pushwheels.

Oxidation gradually consumes the electrode inside the oxygen sensor, so it must be calibrated periodically and occasionally replaced. (See Section 6, "Maintaining the Oxygen Sensor.)

Control Range Computation

The control module establishes four operating parameters directly on from the settings of the four front panel controls:

- The tidal-volume knob sets (V_T), the volume of each breath in mL.
- The rate knob sets (R), the number of breaths per minute.
- The inspiratory flow knob sets (F), the instantaneous gas flow in liters per minute. However, the ventilator doesn't display this flow; instead it calculates and displays the I:E ratio.
- The inspiratory pause button determines the status of the inspiratory pause function, which adds an inspiratory pause—an inflation hold—to the inspiratory cycle.

Then, based on the settings of the tidal volume, rate, and inspiratory flow knobs, the control module calculates three more operating parameters (these calculations assume that the sigh and inspiratory pause functions are off):

$$I = \frac{V_T \times 60}{F \times 1000}$$

- Inspiratory time (I), in seconds, is derived from the tidal-volume and flow settings.

$$E = \frac{60}{R} - I$$

- Expiratory time (E), in seconds, is derived from the inspiratory time and the rate setting.

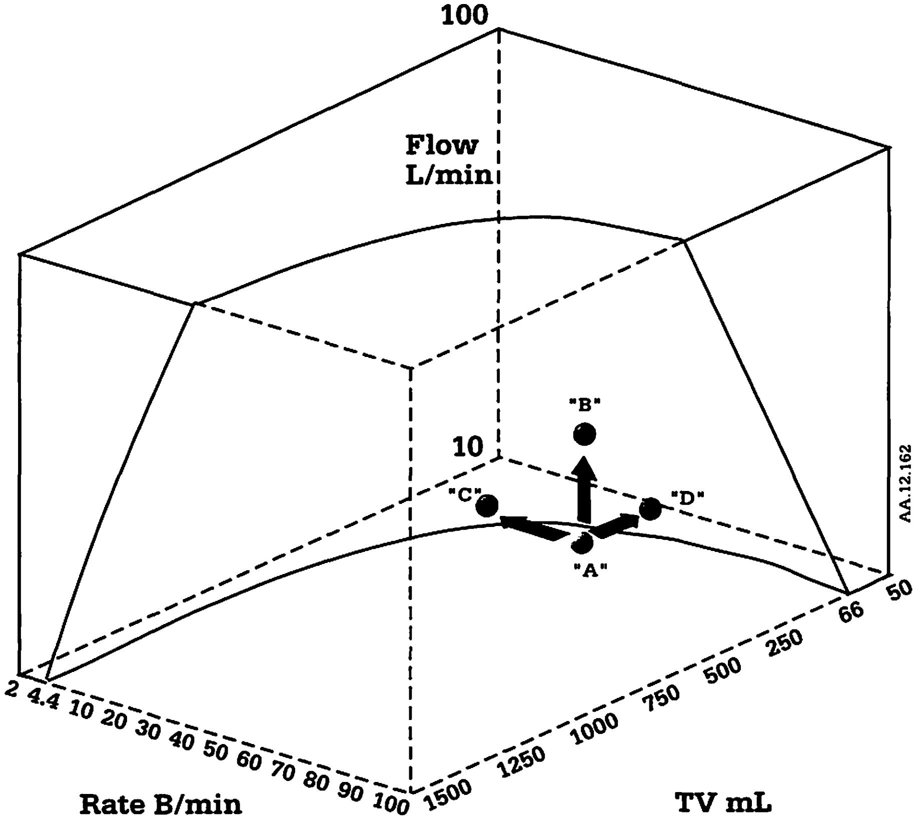
$$I:E = \frac{I}{E}$$

- I:E ratio (I:E), is the ratio of the inspiratory time to the expiratory time. The inspiratory side of the ratio is always expressed as "1." Whenever the inspiratory flow knob is touched, the control module displays the approximated I:E ratio. Because the inspiratory flow is continuously variable within its range, the ventilator's actual I:E ratios are continuously variable from 1:0.5 to 1:999. However, the ventilator displays the I:E ratio rounded to the nearest 0.5.

Although all of the front panel knobs can be set independently to their full-scale limits, certain combinations of the tidal-volume, rate, and inspiratory-flow knobs will result in I:E ratios the ventilator is not designed to deliver. The control module will not accept I:E levels less than 1:0.5. Instead, the ventilator continues to use the most recent acceptable settings, and displays the ventilator setting error message until the I:E ratio is corrected.

For example, if the tidal volume is set to 250 mL, the rate is set to 40 BPM, and the flow is set to 10 liters per minute, the I:E ratio will be only 1:0.33. To increase the I:E ratio to 1:0.5 or more, you must either decrease the tidal volume, decrease the rate, or increase the inspiratory flow. Once the ventilator senses an acceptable control combination, it removes the "vent set error" message and implements the new settings.

Figure 3-20
Diagram of the ventilator's range


100
Flow L/min
10
"B"
"C"
"D"
"A"
2 4.4 10 20 30 40 50 60 70 80 90 100
Rate B/min
1500 1250 1000 750 500 250 66 50
TV mL
AA.12.162

This diagram illustrates the ranges of front-panel control combinations the ventilator is designed to deliver. Control combinations that result in I:E ratios the ventilator can deliver are represented as the solid area at the back of the cube; the cutaway area at the cube's front represents I:E ratios that are out of the ventilator's range. A control combination—as in the example above—of 250 mL tidal volume, 60 BPM rate, and 10 liters per minute flow sets the I:E ratio at point "A," which is in the cutaway area. Increasing the flow moves the point up and out of the cutaway area to point "B." Decreasing the rate moves the point to the left and out of the cutaway area to point "C." And, decreasing the tidal volume moves the point to the right and out of the cutaway area to point "D."

Tidal Volume Compensation

Ventilator measures the patient's actual exhaled volume

You may notice that the exhaled tidal volume (V_T) the ventilator measures and displays usually does not match the setting on the tidal volume knob. In most cases this is normal: the ventilator measures the patient's actual exhaled volume, which—because of a number of factors—will usually be different than the set tidal volume; use the measured volume as a guide when setting tidal volume. Factors contributing to differences between the set tidal volume and the measured tidal volume include breathing system compliance, fresh gas flow, breathing system leakage, the location of the volume sensor within the breathing system, and airway resistance.

Compliance

Because of the compressibility of gases and the expansion of some breathing system components under pressure, not all of the gas delivered from the ventilator enters the patient's lungs. Instead of reaching the patient, some of the gas the ventilator delivers is needed to raise the breathing system pressure to the peak inspiratory pressure. Higher peak inspiratory pressures results in greater tidal-volume losses.

Fresh gas flow

Any fresh gas flow the anesthesia machine introduces to the breathing system during inspiration will be delivered to the patient in addition to the gas the ventilator delivers. Higher fresh gas flows result in greater tidal volumes.

Leakage

Breathing system leakage during inspiration reduces the delivered tidal volume. In a properly maintained breathing system, leakage is usually small enough to ignore when calculating tidal volume compensation.

Location of the volume sensor

When the volume sensor is in the proximal location—on the patient side of the "Y" connector—the ventilator will measure only the patient's exhaled tidal volume. If the volume sensor is placed in the distal location—at the absorber's exhalation check-valve port—the ventilator measures the patient's exhaled tidal volume plus the compliance volume in a portion of the patient circuit that is between the absorber's inhalation and exhalation check valves and the patient; this compliance volume is not delivered to the patient.

Tidal volumes measured distally will always be artificially higher than those measured proximally; the difference between the measurements will usually be small (about 2 to 3 mL/cm H_2O) when standard, 75 to 100 cm (30-to-40-inch) long, patient-circuit tubing is between the absorber and the patient. Adding volume to the circuit, for example by connecting a humidifier in the inspiratory limb, increases the differences between distally and proximally-measured tidal volumes.

Airway resistance

High airway resistance, such as caused by a small endotracheal tube or other airway obstruction, may reduce the tidal volume the ventilator delivers to the patient. A tidal volume delivered at a high inspiratory flow may be partially restricted from reaching the lungs, causing a larger-than-normal portion of that tidal volume to remain in the breathing system. You can determine if airway resistance is a factor in your system: if reducing the inspiratory flow or enabling the inspiratory pause function increases the measured tidal volume, then high airway resistance is a factor.

These breathing system factors may cause the measured tidal volume indicated on the screen to be different than the level you set on the tidal volume knob. During operation compensate for these factors by adjusting the ventilator controls so the measured-and-displayed tidal volume indicates the ventilation level you want to use. Occasionally, however, you may want to calculate an expected tidal volume.

$V_T = V_s + V_{fgf} - V_c$

The exhaled tidal volume you would expect to measure (V_T) equals the tidal volume set on the ventilator (V_s) plus the tidal volume fresh gas flow adds (V_{fgf}) minus the tidal volume lost to breathing system compliance (V_c).

The equation above doesn't account for leakage or high airway resistance. You can compensate for high airway resistance by reducing inspiratory flow or using the inspiratory pause function.

Step One, calculating V_{fgf}, the total volume of fresh gas delivered during inspiration.

$$V_{fgf} = \frac{FGF}{R\left(1 + \frac{E}{I}\right)}$$

- FGF= total fresh gas flow from the anesthesia system, in mL per minute.
- R = breathing rate from the ventilator, in breaths/minute
- $\frac{E}{I}$ = inverse I:E ratio from the ventilator

Step Two, calculating V_c, the volume lost to breathing system compliance.

$V_c = C \times PIP$

C = compliance factor in mL/cm H_2O.

When the volume sensor is in the distal position, the compliance factor (C) for the Ohmeda GMS Absorber is about 8 mL/cm H_2O with adult bellows and about 6 mL/cm H_2O with pediatric bellows; because the volume sensor is located distally, however, actual patient volume will be somewhat less than the tidal volume the ventilator measures and displays. When the volume sensor is in the proximal position, the compliance factor is about 10 mL/cm H_2O for the Ohmeda GMS Absorber with adult bellows, 150 cm (60-inch) long, disposable, patient-circuit tubes, and no humidifier. If your system includes components different from these, see step three to calculate your system's compliance factor.

PIP = peak inspiratory pressure, as shown on the breathing system's pressure gauge, in cm H_2O.

For example, to verify the volume reading of a system connected to either a patient or a test lung: assume that the ventilator settings are V_s = 750 mL (on the tidal volume knob), R = 10/min. (on the rate knob), and the inspiratory flow is set so that I:E = 1:3. Assume also that fresh gas flows total 3 liters per minute (3000 mL per minute), that PIP = 30 cm H_2O (peak inspiratory pressure as shown on the breathing system's pressure gauge), and that the volume sensor is located in the distal position.

$V_{fgf} = \frac{FGF}{R\left(1 + \frac{E}{I}\right)}$, so

$$V_{fgf} = \frac{3000 \text{ mL per minute}}{10/\text{min.}\left(1 + \frac{3}{1}\right)} = 75 \text{ mL}$$

$V_c = C \times PIP$, so $V_c = (8 \text{ mL/cm } H_2O) \times (30 \text{ cm } H_2O) = 240 \text{ mL}$

$V_T = V_s + V_{fgf} - V_c$, so $V_T = 750 \text{ mL} + 75 \text{ mL} - 240 \text{ mL} = 585 \text{ mL}$

The expected tidal volume (V_T) is 585 mL. Because of the number of variables in the equations above, measured tidal volumes within about 15 percent of the calculated value represent a reasonable correlation to the set tidal volume of 750 mL. Leakage will further reduce the measured value.

Step Three. determining the compliance factor. The calculations above use an approximate compliance factor. Occasionally, you may want to determine the compliance for a specific breathing system.

Determining the breathing system compliance factor when the volume sensor is in the proximal position

1. Connect the ventilator's control module and bellows assembly to the breathing system as if ready for use.
2. If applicable, ensure that the absorber is full of absorbent as if ready for use.
3. If applicable, ensure that the absorber's Bag/APL-Ventilator switch is in the "ventilator" position.
4. Connect all of the breathing system components—such as a humidifier, if included in the system, and patient-circuit tubing—as if ready to use.
5. Occlude the patient end—at the "Y" connector—of the patient circuit.

WARNING: When occluding the breathing system for test purposes, do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing-system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for foreign objects.

6. Move the ventilator's mechanical ventilation switch to OFF.
7. Turn all of the fresh-gas flow controls fully clockwise.
8. Power the ventilator ON.
9. Set the tidal volume to 200 mL.
10. Set the rate to 10 B/min.
11. Turn the inspiratory flow knob completely counter-clockwise to 10 liters per minute.
12. Inflate bellows using O2 flush button.
13. Activate the inspiratory pause function.
14. Move the ventilator's mechanical ventilation switch to ON.
15. Adjust the tidal volume knob until the peak inspiratory pressure—shown on the system's pressure gauge—reads exactly 30 cm H2O.

16. Move the ventilator's mechanical ventilation switch to OFF.
17. Touch the tidal volume knob to display the tidal volume that was required to achieve a peak inspiratory pressure of 30 cm H2O. Note the displayed value.
18. $C = \frac{Vs}{PIP}$. Divide the tidal volume value you noted by 30 cm H2O to calculate the compliance of your system.
19. Power the ventilator OFF.
20. Remove the occlusion from the patient circuit.

3.5 Ventilator Modes

Three basic modes

The Ohmeda 7810 Ventilator uses three basic modes:

- **setup page mode,**
  The setup page groups parameters not normally adjusted during a case, such as the screen contrast and the alarm volume.
- **mechanical ventilation mode,**
  In the mechanical ventilation mode--when the mechanical ventilation switch is ON--patient monitoring and alarms are active, and the control module is driving the bellows assembly.
- **non-mechanical ventilation mode.**
  In the non-mechanical ventilation mode--when the mechanical ventilation switch is OFF--mechanical ventilation is OFF, but all patient monitors still function and the alarm system is still active, although certain alarms are enabled only during mechanical ventilation.

When you first enter the setup page, the ventilator displays the ventilator model, the software version number it is using, the selected supply gas setting, the selected language and selected altitude compensation setting. the ventilator then lets you enable or disable the reverse flow alarm and sigh function, and adjust the screen contrast and audio alarm volume. These parameter settings are stored in the ventilator's memory even when the system's power is disconnected; if you are satisfied with these parameter settings, you can skip past the setup page.

In both the non-mechanical ventilation mode and the mechanical ventilation mode, the patient monitoring and the alarms systems are active.

The sigh function

When the sigh function is selected, the ventilator delivers 150 percent of the set tidal volume once every 64th breath. The ventilator accomplishes this by adding 50 percent to the inspiratory and expiratory times while maintaining the set inspiratory flow and I:E ratio. The maximum sigh breath is limited to 1.5 L (1 L plus 50 percent). But if the set tidal volume is 1.4 L, the sigh breath will still be 1.5 L because the inspiratory flow decreases to maintain the I:E and limits the VT to 1.5 L.

To turn ON the sigh function, select "sigh on" from the setup page. Once the sigh function is ON, the ventilator will display "sigh on" on the bottom line of its screen. When the ventilator actually delivers the sigh breath, the ventilator will display "sigh breath." These messages will alternate with other messages the ventilator displays.

When using the sigh function, pay particular attention both to the high pressure alarm setting and to apnea alarms. Because circuit pressure is higher during the sigh breath than during normal cycles, you must set the inspiratory pressure limit knob to compensate for the sigh breath. Also, at low rates the sigh function can cause apnea alarms.

The apnea alarm will be triggered if the ventilator does not sense a complete breath in a 30-second period. At a breath rate of two, the sigh function increases the breath period from 30 seconds to 45 seconds, triggering the apnea alarm.

3.6 Alarm System

When the ventilator senses an alarm condition, it will display an appropriate message, which is updated every one and a half seconds until the condition is resolved (apnea alarms are updated at one second intervals). If a second alarm condition occurs before the first is resolved, the ventilator will alternate the messages for each condition. The ventilator will alternate, at one and a half second intervals, the alarm messages for as many alarm conditions as exist at one time.

Audible alarms

Although when more than one alarm is active the ventilator displays the messages for all of the alarms (by alternating the messages), it sounds the audible alarm for only the highest priority alarm. If that condition is resolved, the ventilator will then sound the alarm for the next highest priority alarm that occurred. The priority of the audible alarms, from high to low, is as follows:

* Warble
* Intermittent
* Continuous
* Single beep

What the LEDs indicate

The two light emitting diodes (LEDs) embedded in the alarm silence button indicate the status of alarms. When an alarm condition first occurs, a message will appear on the screen, a tone will sound, and an LED will flash. Once the alarm silence button is pressed, the ventilator will light the LED continuously to remind you that the alarm condition still exists. The red LED is lighted during alarm conditions that require immediate operator response. The yellow LED indicates alarm conditions that require prompt operator response or operator awareness.

Silencing alarms

To silence an audible alarm, press the alarm silence button. If that alarm condition continues, the alarm will sound again in 30 seconds. If, however, a new alarm condition occurs, its audible alarm will sound immediately. Certain alarms can be silenced permanently, even if the alarm conditions continue. These alarms include power failure, oxygen sensor failure, low battery, ventilator failure, oxygen calibration error, and volume sensor failure.

Ventilator failure messages can indicate anything from a failed ventilator component, transient noise disruption, to excessive pressure in the ventilator's gas supply. All ventilator failure messages except VENT FAIL 6 and DRIVE CKT OPEN will result in the ventilator being stopped. Do not attempt to use the ventilator while a ventilator failure message is displayed. Cycle the system master switch to attempt a ventilator failure message reset. If the ventilator failure message clears, use of the ventilator may be continued with normal observation of ventilator alarms and operation. If the ventilator failure message does not clear, an alternate source of patient ventilation must be used and the ventilator removed form use. Do not use the ventilator if you suspect a malfunction has occurred.

Responding to alarms

See section 5, "Responding to ventilator alarms" for more information.

Alarm quick reference charts

Alarm Message	Alarm Condition	LED	Tone
APNEA **	Insufficient tidal volume measured in greater than 120-second period	Red, flashing	Continuous warble
APNEA ALARM OFF! (Active during non-mechanical ventilation only.)	Tidal volume set to less than 300 mL and mechanical ventilation switch set to OFF	Yellow, continuous	One beep, silences automatically
APNEA xxx SEC	Insufficient tidal volume measured in a greater than 30-second period	Yellow, flashing	Staged: 30 seconds—one warble; 60 seconds—two warbles; 90 seconds—three warbles
CHECK O_2 SENSOR! alternating with CHECK GAS SUPPLY	Measured oxygen less than five percent	Yellow, flashing	Continuous, permanently silenceable
CHECK SETTINGS!	Displayed when setup page is exited	None	One beep, silences automatically
DRIVE CKT OPEN!	Incorrect exhalation valve feedback or pressure switch engaged	Yellow, flashing	Continuous, permanently silenceable
HARDWARE ERROR X	Hardware malfunction	Yellow, flashing	Continuous, permanently silenceable
HIGH OXYGEN!	Oxygen concentration greater than or equal to set limit	Yellow, flashing	Intermittent beep
HIGH PRESSURE!	Circuit pressure above set limit	Red, flashing	Warble per occurrence
LIMIT SET ERROR!	High oxygen alarm limit below or same as Low O_2 alarm limit. Or Low O_2 alarm limit less than 18 percent	Yellow, flashing	Continuous
LOW BATTERY!	Insufficient battery charge	Yellow, flashing	Continuous, permanently silenceable

Alarm quick reference charts (continued)

Alarm Message	Alarm Condition	LED	Tone
LOW MINUTE VOL!	Minute volume below set limit	Yellow, flashing	Intermittent beep
LOW OXYGEN!	Oxygen concentration below set limit	Red, flashing	Continuous warble
LOW PRESSURE! (Active during mechanical ventilation only)	Pressure change less than threshold for at least 20 seconds	Red, flashing	One warble per breath
LOW SUPPLY PRES!	Internal, regulated supply gas pressure less than 152 kPa (22 psig)	Yellow, flashing	Intermittent beep
MAX PRES=xxx cm (Active during non-mechanical ventilation only.)	Pressure limit set to more than 60 cm H_2O	Yellow, continuous	One beep, silences automatically
O2 CAL ERROR!	Measured oxygen greater than 109 percent	Yellow, flashing	Continuous, permanently silenceable
POWER FAIL!	a-c power failure	Yellow, flashing	Continuous, permanently silenceable
REVERSE FLOW! (Active during non-mechanical ventilation only.)	Flow in wrong direction equals volume of more than 100 mL or 20 mL (when tidal volume knob set below 300 mL)	Yellow, flashing	Continuous
REV FLOW ALM OFF	Reverse flow alarm disabled on setup page	Yellow, continuous	None
SIGH ON (Active during mechanical ventilation only.)	Sigh feature on	Yellow, continuous	None
SIGH BREATH (Active during mechanical ventilation only.)	Sigh breath delivered	Yellow, continuous	None
SOFTWARE ERROR X	Invalid data or malfunctioning alarm system	N/A	Tone, permanently silenceable

Alarm quick reference charts (continued)

Alarm Message	Alarm Condition	LED	Tone
SUB-ATMOS PRES!	Pressure less than -10 cm H_2O	Red, flashing	Continuous warble
SUSTAINED PRES!	Pressure exceeds set limit for 15 seconds or more	Red, flashing	Continuous warble
VENT FAIL xx!	Ventilator hardware failure, see Vent Fail definition	Yellow, flashing	Continuous, permanently silenceable
VENT SET ERROR!	Combination of settings of ventilator controls out of range	Yellow, flashing	Continuous
VOL MON STANDBY!	System waiting for first breath to activate volume monitoring and apnea timer	Yellow, continuous	One beep, silences automatically
VOL SENSOR FAIL!	Volume sensor disconnected or defective	Yellow, flashing	Continuous, permanently silenceable
- - - - - - - - ????????	No volume measured during mechanical ventilation	None	None

Alarm definitions

Apnea

If the ventilator doesn't detect a sufficient breath for 30 seconds, an apnea alarm will be generated. The alarm message will indicate the number of seconds that have passed since the last sufficient breath was detected. The tone will warble once at 30 seconds, twice at 60 seconds, and three times at 90 seconds. At 120 seconds the tone will warble continuously and the alarm message will be "apnea ***" only.

The ventilator uses the volume-sensing circuits to activate the apnea alarm. When the ventilator is first powered ON it displays the "VOL MON STANDBY" message to indicate that a set threshold of flow is not being sensed and the apnea alarm is not activated. Then, once the ventilator senses a sufficient volume level, it removes the "VOL MON STANDBY" message and starts a timer that controls the apnea alarm. Each time the ventilator senses sufficient volume, it resets this apnea timer.

The actual volume threshold required to start or reset the apnea timer varies depending on the level you set on the tidal volume knob. For tidal volume settings between 180 mL and 400 mL, the threshold varies linearly from 20 mL to 100 mL. For tidal volume settings below 180 mL, the threshold is always 20 mL. And for tidal volume settings above 400 mL, the threshold is always 100 mL. In the manual mode, however, once the apnea timer starts, the volume threshold required to reset the timer is 20 mL.

For example, if the tidal volume knob is set to 250 mL, and mechanical ventilation is switched ON, the timer starts and is reset when the ventilator senses a breath of at least 46 mL. If you then increase the tidal volume knob to 320 mL, the ventilator will increase the threshold to 71 mL. In either case, if the timer reaches 30 seconds (because the ventilator didn't sense enough volume to indicate a breath), the first in the series of four apnea alarms will sound.

Apnea alarm off

Because very low flow levels that are not sufficient to trigger the volume-sensing circuits may occur in spontaneously breathing patients, the ventilator disables the apnea alarm when the tidal volume knob is set to less than 300 mL and mechanical ventilation is switched to OFF.

Whenever tidal volume is set to less than 300 mL and the mechanical ventilation switch is OFF, the ventilator, once it has detected a breath, will display "apnea alarm off." To enable the apnea alarm while the patient is breathing spontaneously, increase the tidal volume knob to 300 mL or more. Although you should always carefully set the low minute volume pushwheel to enable the low minute volume alarm at an appropriate level, the low minute volume alarm is especially important when the tidal volume knob is set to less than 300 mL, disabling the apnea alarm.

Check O_2 sensor/ check gas supply

If the ventilator detects less than five percent oxygen, it assumes that either the oxygen sensor has failed or that insufficient oxygen is in the breathing system, and it generates an alarm. A check O_2 sensor/check gas supply alarm will also be generated if the sensor isn't connected correctly, if the sensor is broken, or if no oxygen is in the area of the sensor.

Check settings

In the setup page the front panel controls are used to set parameters not normally adjusted during a case, such as the screen contrast and the alarm volume. Before you use the ventilator on a patient, you must readjust any controls you used in the setup page. To remind you to check your control settings, when you exit the setup page, the ventilator displays the "check settings" message.

Drive circuit open

One type of ventilator failure--exhalation valve failure--does not display a numbered message; instead, DRIVE CKT OPEN is displayed. This message can also appear if, during mechanical ventilation, the absorber's Bag/APL-ventilation switch is in the "BAG/APL" position. During this alarm, the ventilator will attempt to continue monitoring and mechanical ventilation.

1. Check the patient.

2. If mechanical ventilation is ON, make sure the absorber's Bag/APL-ventilation switch is in the "ventilator" position, if applicable.

Hardware error

This display (error A, B, C) and alarm should not occur unless there is a problem with the ventilator control module hardware. The alarm is silenceable with the alarm silence button. Mechanical ventilation does not turn OFF.

⚠ **WARNING: Do not use the ventilator if this display and alarm occur.**

High oxygen

If the ventilator detects an oxygen concentration equal to or higher than the one you set using the high-O_2 pushwheel, the ventilator will generate a high oxygen alarm.

High pressure

If, during mechanical ventilation or while in the non-mechanical ventilation mode, the ventilator detects airway pressure higher than the limit you set using the inspiratory pressure limit control, the ventilator will generate a high pressure alarm. In addition, during mechanical ventilation only, the ventilator uses automatic, high-pressure relief to manage excessive airway pressure. If, while the mechanical ventilation switch is ON, the airway pressure rises to a level that causes a high pressure alarm, the ventilator will release the remaining drive gas into the atmosphere and end inspiration.

Limit setting error

If you attempt to set the high oxygen alarm limit for a level below or equal to the low oxygen limit, the ventilator will generate a limit setting error alarm. This alarm will also be generated if you attempt to set the low oxygen alarm limit for less than 18 percent.

Low battery

Two sources can power the control module: the Ohmeda Modulus II Plus Anesthesia System's d-c power supply and the system's backup battery. If the anesthesia machine's d-c power supply fails, either because of an electronic failure or because the anesthesia system's a-c power is lost, then its backup battery takes over. The battery supplies 12 volts, which a device in the anesthesia machine converts to five volts for the ventilator to use.

If the voltage from the anesthesia machine drops to a certain level or below, the ventilator generates a low battery alarm. Pressing the alarm silence button 🔇 permanently silences the alarm tone; however, the LED remains lighted and the alarm message still appears.

Low minute volume

If the ventilator detects that the minute volume is less than the level you set using the low minute volume pushwheel, the ventilator will generate an alarm. To reduce nuisance alarms that can be generated when control settings are changed, whenever you adjust the tidal volume knob or the rate knob, move the mechanical ventilation switch to ON, or exit the volume monitor standby condition, the ventilator will disable the low minute volume alarm for 40 seconds.

⚠ **WARNING: Always correctly set the low minute volume alarm and use CO_2 monitoring to aid in the detection of breathing system disconnections.**

Low oxygen

If the ventilator detects an oxygen concentration lower than the one you set using the low-O_2 pushwheel, the ventilator will generate a low oxygen alarm.

Low pressure

The ventilator generates a low pressure alarm if, for at least 20 seconds, the airway pressure fails to change by a value that varies proportionally to the setting of the inspiratory flow knob. To determine the change in airway pressure, the system compares the airway pressure at a point 50 milliseconds after the peak pressure to a point at the end of patient exhalation.

The amount of change required to prevent an alarm from triggering will vary between 4 cm H_2O to 9 cm H_2O to correspond to the inspiratory flow range of 10 liters per minute to 100 liters per minute. For example, if the inspiratory flow is set to 30 liters per minute, the low pressure alarm will activate if the pressure doesn't change by at least 5.1 cm H_2O. But if the inspiratory flow is set to 80 liters per minute, the change must be at least 7.9 cm H_2O to keep the alarm from activating.

Unlike other alarms, the low pressure alarm is active only when mechanical ventilation is switched ON.

Low supply pressure

If the ventilator's internal, regulated supply gas pressure is less than 152 kPa (22 psig.) the ventilator will generate a low supply pressure alarm.

Maximum pressure limit

Anytime you adjust the inspiratory pressure limit knob, the ventilator will briefly display the pressure limit in centimeters of water. However, if the ventilator is in the non-mechanical ventilation mode and the inspiratory pressure limit is set to more than 60 cm H_2O, the ventilator will also light the yellow alarm LED and will continuously display the "max pres=xxx cm" reminder. The pressure limit reminder is displayed in the non-mechanical ventilation mode only; during mechanical ventilation this reminder is disabled.

Oxygen calibration error

Some oxygen sensors may deliver a signal that is out of the ventilator's range. If the ventilator senses too large of a sensor signal, it will display the "O_2 cal error" message. To remove the message, continue to turn the O_2 calibration knob.

Reverse flow

If the ventilator senses reverse flow of an unacceptable volume, it will generate an alarm. The volume that will trigger a reverse flow alarm depends on the tidal volume you set. If you set the tidal volume knob for less than 300 mL, then 20 mL or more will trigger an alarm. However, if you set the tidal volume knob for 300 mL or more, the ventilator will allow up to 100 mL before triggering an alarm. Once the alarm has been triggered, two forward breaths must be sensed before the ventilator will automatically switch OFF the alarm.

The reverse flow alarm is intended to warn you of inadvertent reverse flow conditions, such as those caused by a defective or sticking exhalation check valve. These kinds of conditions will be detected only when the volume sensor is correctly placed at the distal position of the expiratory limb of the breathing system. If you place the volume sensor at the proximal end of the "Y" connector, volume monitoring will still function. However, when the volume sensor is located at the proximal position, a reverse flow condition will exist each time the patient inhales and the reverse flow alarm will activate for each breath. To disable the reverse flow alarm, select "rev flow alm off" from the setup page (see "Using the setup page in "Operating the System").

⚠ **WARNING: The reverse flow alarm will function correctly only if the volume sensor cartridge is working correctly and is properly placed in the distal position of the expiratory limb of the breathing system.**

⚠ **WARNING: When the volume sensor is in the distal position of the breathing system, check the ventilator's setup page to confirm that the reverse flow alarm is enabled. Do not use the system with the reverse flow alarm disabled if the volume sensor is in the distal position.**

Reverse flow alarm off

To advise you that the reverse flow alarm is disabled, in the non-mechanical ventilation mode the ventilator will repeatedly flash this message. If you power ON the control module with the alarm disabled and mechanical ventilation ON (although you should always have the mechanical ventilation switch set to OFF when you power ON), the message will be displayed once.

Placing the volume sensor cartridge at the distal position in the expiratory limb lets the system detect reverse flow and generate reverse flow alarms. You may also place the volume sensor cartridge at the proximal end of the "Y" connector; however, you then must use the setup page to disable the reverse flow alarms that would otherwise be generated when the patient inhales.

Sigh alarms

The message "Sigh Breath" replaces sigh on until the next breath is delivered.

Software error

This display (errors A through F) and alarm should not occur unless there is a problem with the ventilator software programs. The alarm is silenceable with the alarm silence button. Mechanical ventilation does not turn OFF.

WARNING: Do not use the ventilator if this display and alarm occur.

Subatmospheric pressure

If the ventilator detects airway pressure of less than -10 cm H_2O, it will generate a sub atmospheric pressure alarm. For example, airway pressure of -12 cm H_2O will cause an alarm.

Sustained pressure

The ventilator sets the sustained pressure limit to correspond to the inspiratory pressure limit knob's setting. For maximum inspiratory pressure limits of 20 cm H_2O to 60 cm H_2O the ventilator sets the sustained pressure limit to one half the inspiratory pressure limit. For example, if the inspiratory pressure limit is 42 cm H_2O, the sustained pressure limit will be 21 cm H_2O. However, any inspiratory pressure limit setting of more than 60 cm H_2O will result in a sustained pressure limit of 30 cm H_2O. For example, inspiratory pressure limits of 65 cm H_2O and 80 cm H_2O will both result in a sustained pressure limit of 30 cm H_2O. Anytime the airway pressure exceeds (for 15 seconds or more) the sustained pressure limit set by the inspiratory pressure limit knob, the ventilator will generate a sustained pressure alarm.

Ventilator failure

Ventilator failure messages can indicate anything from a failed ventilator component, transient noise disruption, to excessive pressure in the ventilator's gas supply. All ventilator failure messages except VENT FAIL 6 and DRIVE CKT OPEN will result in the ventilator being stopped. Do not attempt to use the ventilator while a ventilator failure message is displayed. Cycle the system master switch to attempt a ventilator failure message reset. If the ventilator failure message clears, use of the ventilator may be continued with normal observation of ventilator alarms and operation. If the ventilator failure message does not clear, an alternate source of patient ventilation must be used and the ventilator removed form use. Do not use the ventilator if you suspect a malfunction has occurred.

IMPORTANT

If the ventilator experiences extreme electrical interference, it may interrupt mechanical ventilation. If this interruption occurs, the ventilator generates an internal reset function and resumes normal operation after two (2) seconds. For situations where continuous electrical interference is experienced by the ventilator, causing a continuous interruption, the ventilator's internal reset repeats until the interference ceases.

If the electrical interference is continuously present and mechanical ventilation is interrupted for approximately 30 seconds, the ventilator produces a continuous beeping audio alarm. Manual ventilation of the patient must be performed while the mechanical ventilation is interrupted. When the electrical interference ceases, the continuous beeping audio alarm can be silenced only by turning the anesthesia machine power switch to OFF and after five seconds back ON.

WARNING: Manual ventilation must be performed when electrical interference causes interruption of ventilator delivered mechanical ventilation. Manual ventilation must be continued until the ventilator resumes normal operation or an alternate ventilator/anesthesia system can be used.

WARNING: The use of electrosurgical units or other device that radiate high-intensity electrical fields can affect the operation of the ventilator and monitors attached to the patient. Maintain as much distance as possible between the electrosurgical leads and the cables to the flow and oxygen sensors. Do not drape the electrosurgical leads across the absorber or the anesthesia machine. Do not let the electrosurgical leads rest on any surface of the anesthesia system. Constant surveillance of all monitoring and life support equipment is mandatory whenever electrosurgical devices are in operation, on, or in the vicinity of the patient.

Ventilator setting error

If you attempt to set a combination of the inspiratory flow, tidal volume, rate, and inspiratory pause controls that results in a level the ventilator is not designed to deliver, the ventilator will continue to use the most recent acceptable settings, and will generate a "VENT SET ERROR" alarm until the control combination is corrected. For example, a tidal volume of 500 mL, combined with a rate of 20 B/min., and an inspiratory flow of 10 liters per minute will trigger a ventilator setting error. To remove the error, either decrease the tidal volume setting, or decrease the rate setting, or increase the flow setting.

WARNING: Do not use the ventilator while the "vent set error" message is displayed; when this message is displayed, the control settings do not reflect the settings the ventilator is using. If the "vent set error " message is displayed during mechanical ventilation, the system will use the most recent acceptable settings. If, however, the ventilator is powered ON in the "vent set error" condition, moving the ventilation switch to ON will not start mechanical ventilation until the controls are moved to an acceptable setting.

Volume monitor standby

When the ventilator is first powered ON, or when the ventilator is switched from mechanical ventilation to the non-mechanical ventilation mode, or when--while the ventilator is in the non-mechanical ventilation mode--the alarm silence button is pressed, the ventilator displays the "VOL MON STANDBY" message to indicate that the alarm system is waiting for a sufficient breath. Once the ventilator senses a sufficient volume level, it removes the "VOL MON STANDBY" message and starts the timers that control the apnea alarms.

Volume sensor failure

This message will be displayed if the volume sensor's heater voltage is too low, which can happen if the volume sensor clip is broken or disconnected.

Dashes displayed in place of readings

If the system doesn't measure any volume during mechanical ventilation, it will display dashes in place of the volume and rate data.

Question marks displayed in place of readings

Certain combinations of ventilator front panel control settings can result in ventilation conditions the ventilator can deliver but the volume sensor cannot measure. If you set a control combination the ventilator can deliver, but the volume monitor cannot measure, or if--in the non-mechanical ventilation mode--breathing occurs that the monitor cannot measure, the ventilator will display question marks in place of the V_T,V_E, and rate readings.

4/Preoperative Checkout Procedures

4.1 Perform These Checkout Procedures Before Each Case

Before starting the preoperative checkout procedures

WARNING: Always complete the following checkout procedures before using the Ohmeda Modulus II Plus Anesthesia System on a patient. Perform these procedures prior to each case using the actual room, pipeline gas supply and electrical supply that will be used during the case.

WARNING: Ensure that all hoses, tubing and other circuit connections are made properly before using this anesthesia system. Failure to do so may cause injury to the patient. Refer the operation manuals for accessory equipment.

This section of the manual describes the minimum checks that should be made before the Modulus II Plus Anesthesia System is used on a patient. If the system does not pass all of the steps in these procedures, consult the troubleshooting guide, section 7. Do not use the system if it does not function correctly as described in the preoperative checkout procedures; instead call a qualified service representative.

WARNING: Do not attempt to use the anesthesia system without first ensuring that the complete system, including all accessory equipment, is operating properly. A damaged or malfunctioning anesthesia system could result in patient injury

In addition to the procedures listed here, individual preoperative checklists for this system and its options and accessories are included in the front of the system's binder. Before each case review these checklists. They are intended to serve only as reminders of the complete checkout procedures listed in the operation-and-maintenance manuals for the devices. Always complete the checkout procedures for all the devices in the system.

Before starting the preoperative checkout procedures, visually check the system

1. Make certain the breathing circuit is complete, undamaged and, if appropriate, the absorber contains adequate CO_2 absorbent.

2. Ensure that the following are not damaged:
    a. Cylinder yokes
    b. Pipeline inlets
    c. Flowmeters and flow control valves
    d. Pressure gauges
    e. Vaporizers
    f. Monitors and cables
    g. All hoses and tubing

3. Check that the breathing circuit is closed and connected to a gas scavenging system.

4. Check that the cylinders are properly installed.

5. Check that the machine frame is sound and frame members are tightly attached.

6. Ensure the drawers operated smoothly.
7. Check that the vaporizers are properly installed.
8. Ensure that the shelves are not overloaded.
9. Check that the cylinder wrench is available.
10. Check that the caster brake is set.
11. Check the condition of casters and free movement.
12. Check that require emergency equipment is available and in working order.

4.2 Checking The Pipeline And Reserve Cylinder Supply

1. Make sure a gas cylinder or cylinder yoke plug is properly and securely mounted in each cylinder hanger yoke.
2. Disconnect the pipeline supply hoses from the wall outlets.
3. Move the system master switch to OFF.
4. Open the flow control valves by turning their knobs fully counterclockwise.

CAUTION: Open the cylinder valves s-l-o-w-l-y to avoid damaging the regulators.

5. Open each cylinder valve and check the cylinder pressure gauges to verify that the cylinder supplies are adequate. Make a note of all the cylinder pressures.
6. If you are using a second oxygen yoke:
   a. Close the first cylinder.
   b. Press the oxygen flush button to release the pressure from the first cylinder.
   c. Open the second cylinder and check its pressure.
7. Check that none of the flowmeters indicate gas flow.
8. Close all of the cylinder valves and note the value on each cylinder pressure gauge. The gauges must show less than a 690 kPa (100 psig) pressure drop in a five minute period. If there is a visible pressure drops after one minute, the high-pressure circuit has an unacceptable leak.

If the circuit is leaking excessively:

   a. Defective cylinder gaskets or loose tee handles can cause such leaks. Replace the gasket and tighten the tee handle.

b. Repeat the leak check. If the circuit still leaks, do not use the system for clinical applications. Call a qualified service representative for repairs.

Check hospital pipeline

9. Check the anesthesia machine-to-hospital pipeline connections.

a. Turn the system master switch to ON.

b. Open all of the flow control valves to return the cylinder pressure gauges to zero.

c. Turn the system master switch to OFF.

d. Close all of the flow control valves.

O_2 pipeline hose

e. Connect the hospital O_2 pipeline hose to the system's O_2 pipeline inlet. Ensure that the O_2 pipeline supply pressure, which should be about 345 kPa (50 psig), is indicated on the O_2 pipeline pressure gauge only.

f. Turn the system master switch to ON.

g. Fully open-all of the flow control valves.

h. Ensure that only the O_2 flowmeter indicates flow.

i. Close all of the flow control valves.

N_2O pipeline hose

j. Connect the hospital N_2O pipeline hose to the system's N_2O pipeline inlet. Ensure that the N_2O pipeline supply pressure, which should be about 345 kPa (50 psig), is indicated on the N_2O pipeline pressure gauge only.

k. Fully open the N_2O and, if included in your system, the third-gas flow control valves. As you open the N_2O flow control valve, the Ohmeda Proportion Limiting Control System will engage, increasing the O_2 flow.

l. Ensure that the N_2O flowmeter indicates flow.

m. Ensure that the third-gas flowmeter indicates zero flow.

n. Close all of the flow control valves.

o. Disconnect the N_2O pipeline supply from the system.

p. Fully open the N_2O flow control valve to return the N_2O pressure gauge to zero.

q. Close all of the flow control valves.

Pipeline air

r. If your system includes pipeline air, connect the hospital air pipeline supply to the system's air pipeline inlet. Ensure that the air pipeline supply pressure, which should be about 345 kPa (50 psig), is indicated on the air pipeline pressure gauge only.

s. Fully open the N_2O and Air flow control valves. As you open the N_2O flow control valve, the Ohmeda Link 25 Proportion Limiting Control System will engage, increasing the O_2 flow.

t. Ensure that the N_2O flowmeter indicates zero flow.

u. Close all of the flow control valves.

4.3 Checking The Low Pressure Gas Circuitry

Before performing this test, check the pipeline supply pressure as described in the previous section.

WARNING: Leaking gases and vapors (downstream of the flow control valves and Oxygen Flush valve) may deprive the patient of metabolic gases and anesthetic agent and may pollute the atmosphere. Tests that detect such leaks must be performed frequently. If detected, leakage must be reduced to an acceptable level.

Low-pressure leak-testing device

A low-pressure leak-testing device is included with all Modulus II Plus Anesthesia Systems. Store this device, which should always be kept with the system, in one of the gas machine's drawers. Perform the low-pressure leak test with the cylinders installed.

The leak-testing device must be in good condition to reliably perform the low-pressure circuit leak test. At least once every six months test the device's ability to produce a partial vacuum of 65-mm Hg or greater.

Check The Leak Tester For Vacuum Production

1. Connect the device to a suitable vacuum gauge.
2. Squeeze and release the bulb to obtain progressively greater displacements. Replace the leak testing device if—while the bulb is still deformed—the device produces a partial vacuum less than 65-mm Hg.

Check Low Pressure Gas Circuitry

1. Check the condition of the low pressure leak-testing device.
    a. Seal the device's inlet connector and squeeze the bulb until it collapses.
    b. Release the bulb and check the time it takes to reinflate.
    c. Replace the leak testing device if reinflation occurs in less than a minute.
2. Turn the system master switch to OFF, if it is not OFF already.
3. Switch OFF the vaporizers.
4. Open each gas supply either by slowly opening the cylinder valves or by connecting the pipeline hoses.

5. Fully open all of the flow control valves.

6. Disconnect the gas supply tubing from the common gas outlet.

7. Attach the leak testing device to the common gas outlet.

8. Repeatedly squeeze and release the hand bulb until it collapses and remains collapsed. Once the bulb stays closed, check how long it takes to reinflate. If the hand bulb reinflates in less than 30 seconds, the low-pressure circuit has an unacceptable leak.

Vaporizer leak check

9. For each mounted vaporizer:
   a. Make sure the vaporizer is properly mounted and that the filler and drain valves are closed tightly.

   b. Turn the vaporizer concentration control dial to one percent.

   c. Repeat step eight. If the circuit does not pass the test, the leak is in the vaporizer. Remove leaking vaporizers from service.

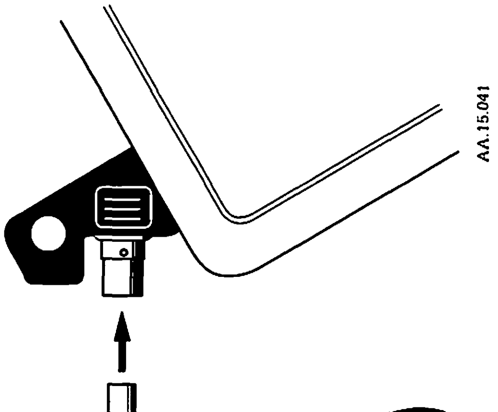
   d. Switch OFF the vaporizer.

10. Remove the low pressure leak testing device from the common gas outlet.

11. Turn each vaporizer ON and then OFF after a leak check to rid the system of residual vacuum.

12. With all vaporizers switched OFF, purge the circuit with a flow of 1 liter per minute oxygen flow for one minute.

Figure 4-1 Low-pressure leak-testing device



WARNING: Do not use the anesthesia system after performing the low-pressure leak test until the vaporizer circuits have been purged with oxygen. Using a system that has not been purged with oxygen may result in incorrect gas mixtures, and injury to the patient.

4.4 Checking The Gas Flow Controls

1. Turn all of the flow control valve knobs completely clockwise to close the flow control valves. Do not over tighten the valves, finger tight is sufficient.

2. Either connect the pipeline supplies or slowly open the cylinder valves.

3. Turn the system master switch to ON.

- The oxygen flowmeter should show about 200 milliliters per minute (50 milliliters per minute, low flow systems). The other flowmeters should show no gas flow.

Adjust N_2O flow control valve

4. This step tests the function of the Ohmeda Proportion Limiting Control System when the nitrous oxide knob is adjusted. During these tests use only the nitrous-oxide flow-control valve; perform the checks from low to high flows; and do not overshoot any setting. If you overshoot a setting, repeat this section starting at step one.

Table A.1

Set the N_2O Flow control valve So flow reads	O_2 flow should read	Minimum O_2 flow	Maximum O_2 flow	O_2 monitor
0.9	0.3	0.24	0.36	20% to 30%
1.5	0.5	0.4	0.61	20% to 30%
3.0	1.0	0.7	1.22	20% to 30%
6.0	2.0	1.58	2.44	20% to 30%
9.0	3.0	2.37	3.66	20% to 30%
12.0	4.0	3.16	4.89	20% to 30%

Adjust O_2 flow control valve

5. This step tests the function of the Ohmeda Link 25 Proportion Limiting Control System when the oxygen flow knob is adjusted. During these tests use only the oxygen flow control valve.

- Be careful not to overshoot any setting. If you overshoot a setting, repeat this step starting at "a." Perform these checks from high to low flows.
  a. Increase the oxygen flow to 6 liters per minute.
  b. Reduce the oxygen flow to 3 liters per minute.

Table B.1

Set the O_2 flow control valve so flow reads	N_2O flow should read	Minimum N_2O flow	Maximum N_2O flow	O_2 monitor
3.0	9.0	7.36	11.41	20% to 30%
1.0	3.0	2.46	3.80	20% to 30%
0.5	1.5	1.23	1.90	20% to 30%
0.3	0.9	0.74	1.14	20% to 30%

WARNING: Do not use the anesthesia system if the Ohmeda Link 25 Proportion Limiting Control System does not operate within permitted ranges. Using an incorrectly operating control system may result in incorrect gas mixtures, and injury to the patient.

6. Adjust all of the gas flows to mid-scale. While you are turning the flowmeter knobs, the flowmeter floats must move smoothly.

Check low O_2 alarm

7. Shut OFF the oxygen supply either by closing the oxygen cylinder valve, or by disconnecting the oxygen pipeline supply. As pressure bleeds off:

- The oxygen-supply failure alarm must continuously sound.
- The green, oxygen-supply indicator labeled "Normal" must extinguish.
- The red, oxygen-supply indicator labeled "Fail" must flash.
- All gas flow must fall to zero, with oxygen being the last gas to stop flowing.

8. Turn all of the flow control valve knobs completely clockwise to close the flow control valves. Do not over tighten the valves.

9. Either reconnect the oxygen pipeline supply or slowly open the oxygen cylinder valve. Once the oxygen supply is restored:

- The oxygen supply alarm must be silenced.
- The red, oxygen supply indicator labeled "Fail" must extinguish.
- The green, oxygen supply indicator labeled "Normal" must light.

4.5 Testing The Anesthesia Machine Electrical Alarms

1. Move the system master switch to ON.

2. Unplug the power cord.

   The electrical disconnect/failure alarm must activate, the green "Mains" indicator must go out, a battery indicator bar must light, and the red "Battery" electrical power indicator must flash.

3. Plug in the power cord and observe that: the "Battery" indicator stops flashing and the tone is silenced; the battery indicator bar is extinguished; and the "Mains" electrical power indicator is lit.

4. Check that:

- All system monitors are powered ON .
- No monitor is in its battery mode.

5. Check the alarms of any installed monitors as described in their individual operation-and-maintenance manuals.

4.6 Checking The Battery

Pressing the battery test button, which is on the patient interface panel, momentarily connects the system's built-in backup battery to the battery condition indicator on the master switch panel. Before each case—while the system's master switched is ON —press the battery test button to test the system's backup battery.

When you press the battery test button, either a colored bar or "fail" is lighted to indicate the backup battery's condition, unless the battery is completely discharged. When the battery is fully charged, the left-most green-indicator bar is lighted. As the battery becomes progressively weaker, the lit bar moves from green, to yellow, and then to red. When the battery is almost completely discharged, the system flashes the red "fail" indicator. If the battery is completely discharged, the system switches itself off. Do not use the system unless the battery is fully charged. If, however, the battery fails during an a-c power outage, you can use the battery bypass button to restart the system once a-c power is restored.

1. Switch OFF the anesthesia system master switch.
2. Move the ventilator's mechanical ventilation switch to OFF.
3. Switch ON the anesthesia system.

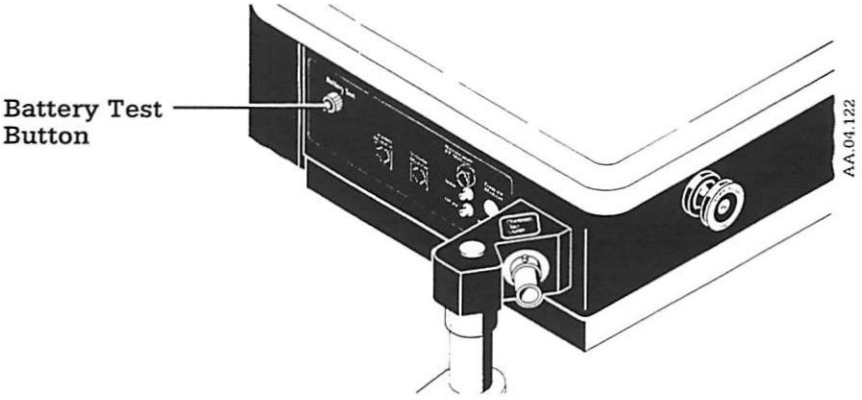


Figure 4-2
Location of the battery test button

4. Press the battery test button, which is on the patient interface panel.

- The battery condition indicator, to the left of the anesthesia system's master switch, must light a green bar indicating that the battery is in good condition. If a yellow or red bar or the "fail" indicator is lighted, or if the system switches off, have trained service personnel replace the battery.

5. Switch OFF the anesthesia system.

WARNING: Do not use the anesthesia system if the backup battery is not in good condition. If the backup battery does not function correctly, the anesthesia system's backup power will not function correctly, which may result in a loss of both mechanical ventilation and the ventilator's integrated monitoring if the system's primary power source is removed.

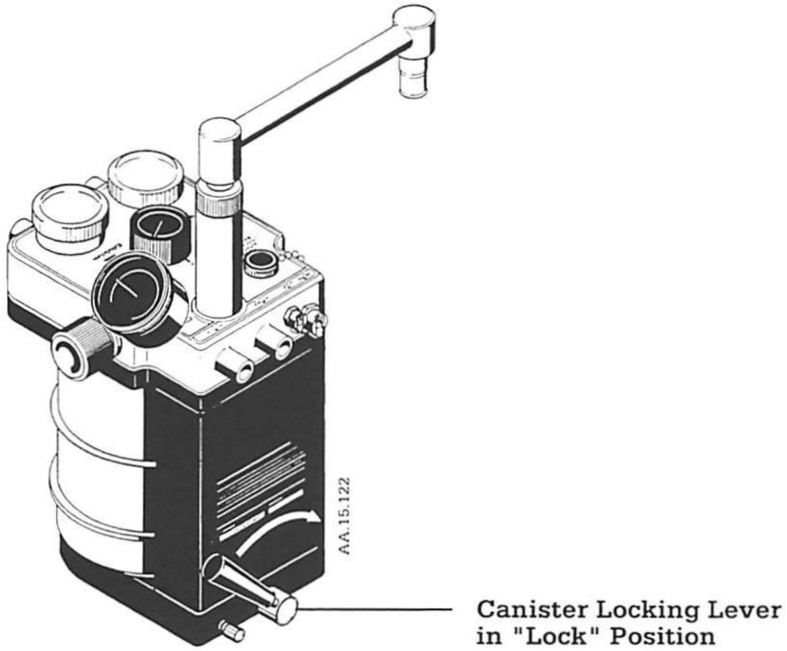
4.7 Testing The Breathing System

Before each case test the breathing system, which, as throughout this manual, includes the ventilator's bellows assembly and the Ohmeda GMS Absorber. If your system includes other components, consult the literature for those devices and consider their affect on the performance of the entire breathing system. Although this section does mention the Ohmeda GMS Absorber, you should refer to the absorber's operation and maintenance manual for a detailed description of using, maintaining, and testing the Ohmeda GMS Absorber.

General Breathing System Checks

1. Verify that any breathing system condensate has been drained and that the drain is completely closed.
2. Verify that the tubing connecting the volume sensor to the patient circuit is draped away from the turbine connections to keep collected condensate away from the turbine vanes.
3. Verify that the capacity of the absorbent is adequate for the case.
4. Verify that the canisters are properly seated and that the canister locking lever is in the "Lock" position. (See figure 4-3.)
5. Verify that the Ohmeda GMS Absorber's pressure gauge is zeroed when the system is open to atmosphere.

Figure 4-3
Ohmeda GMS absorber



Testing The Absorber Bag/APL Circuit

1. Turn the Bag/APL-Ventilator switch to the "Bag/APL" position.

Breathing system leak test

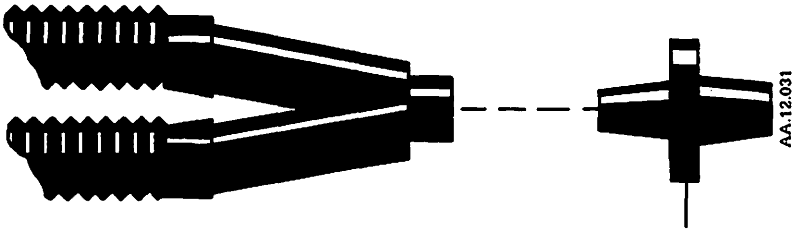
2. Perform the breathing system leak test:

   a. Close the APL valve by turning the APL valve knob fully clockwise. Then rotate the knob counter-clockwise one-quarter turn to partially open the valve.

   b. Set the anesthesia machine for a oxygen flow of 200 milliliters per minute delivered to the breathing system.

   c. Occlude the rebreathing bag nipple and the patient end—at the "Y" connector—of the patient circuit.

Figure 4-4
Occluding the "Y" connector



Test Plug
2900-0001-000

WARNING: When occluding the breathing system for test purposes use Ohmeda's Test Plug (2900-0001-000). Do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing-system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for foreign objects.

   d. Watch the absorber's pressure gauge. Press the oxygen flush button briefly to pressurize the breathing system to just under 40 cm H_2O. The bellows must not move. Any movement indicates unacceptable cross-leakage between the bag/APL and ventilator circuits.

   e. Continue to watch the pressure gauge. The 200 milliliters per minute oxygen flow from the anesthesia machine should raise the breathing system's pressure to at least 40 cm H_2O. The leakage of the bag/APL circuit is then less than or equal to 200 milliliters per minute at 40 cm H_2O.

APL valve tests

3. Perform the APL valve tests:

   a. Rotate the APL valve knob fully clockwise.

   b. Increase the oxygen flow to 3.0 liters per minute. The pressure on the absorber's pressure gauge should increase to between 65 cm H_2O and 80 cm H_2O. This checks the maximum pressure limit in the bag/APL circuit.

c. Slowly turn the APL valve knob counterclockwise in one-quarter-turn increments. The pressure should drop, then stabilize, with each turn of the knob. This checks the adjustable pressure-limiting function of the valve.

d. The APL valve knob should now be fully counterclockwise. Remove the occlusion in the breathing system bag nipple.

e. Connect the breathing bag you are planning to use for the next case to the breathing system bag nipple. The 3.0 liters per minute flow should fill the breathing bag to its nominal capacity. The pressure should stabilize between 1.0 cm H_2O and 7.0 cm H_2O. This ensures that the breathing bag fills for spontaneous breathing with the APL valve completely open, but limits the positive pressure in the circuit.

4. Reduce the oxygen flow delivered to the breathing system to 200 milliliters per minute.
5. Remove any occlusions you have added to the breathing system.

Testing The Ventilator Circuit

1. Occlude the patient end—at the "Y" connector—of the patient circuit, see figure 4-4.
2. Turn the Bag/APL-Ventilator switch to the "Ventilator" position.

WARNING: When occluding the breathing system for test purposes use Ohmeda's Test Plug (2900-0001-000). Do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing-system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for foreign objects.

3. Watch the absorber's pressure gauge. Press the oxygen flush button to fill the bellows. When full the bellows may swell, but it must remained installed on the bellows base. The pressure gauge reading must not exceed 15 cm H_2O.
4. Examine the bellows and confirm that it is undamaged.
5. Release the oxygen flush button.
6. Watch the pressure gauge and adjust the oxygen flow from 200 milliliters per minute to 10 liters per minute and back. The pressure reading must stay within the range of 1.0 cm H_2O and 5.0 cm H_2O. This tests the bellows assembly's pressure relief valve.
7. Switch OFF the anesthesia machine. The bellows must not drop more than 100 milliliters per minute. If the bellows drops more than 100 milliliters per minute, either the bellows is leaking or the pressure relief valve is not functioning properly.
8. If any leak cannot be corrected, do not use the ventilator; have a qualified service representative make repairs.

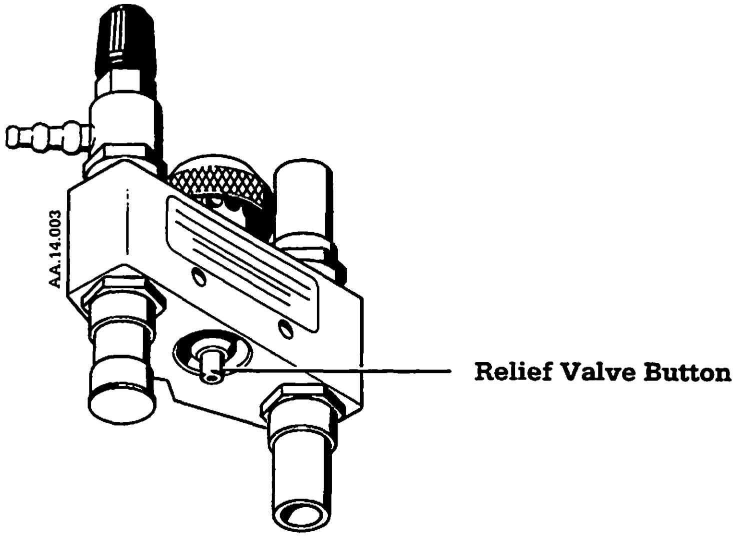
9. Remove any occlusions you have added to the system.

4.8 Testing The Scavenging Interface Relief Valve

The relief valve button, which is on the assembly's underside, must freely move up and down. If the button does not move freely, the relief valve is malfunctioning; do not use the assembly if the relief valve button indicates a malfunction.

To test the valve, reach under the assembly and push up, then release, the button. The button must immediately drop back to its lower position.

Figure 4-5
Testing the scavenging interface valve



4.9 Checking The Ventilator Connections

Before you use the ventilator on a patient, check that all of the ventilator connections are correct and secure.

Figure 4-6
The anesthesia system's electrical power cord must be plugged into a grounded, hospital-grade receptacle.

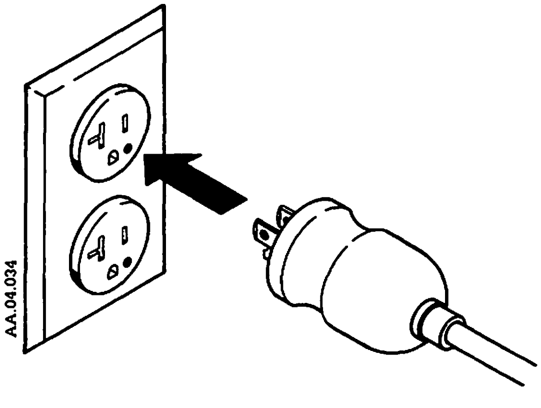


Figure 4-7
One end of the 17-mm corrugated tube must be connected to the 90-degree adapter labeled "Connect to Bellows Ass'y Inlet" on the control module.

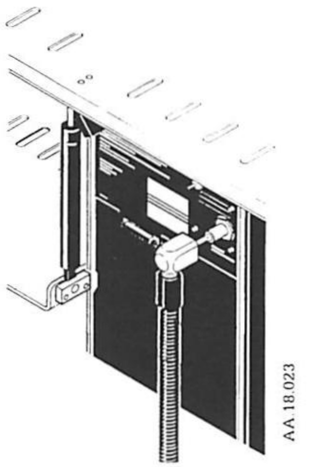


Figure 4-8
The center of this 17-mm corrugated tube must be connected to the bracket on the anesthesia system's side.

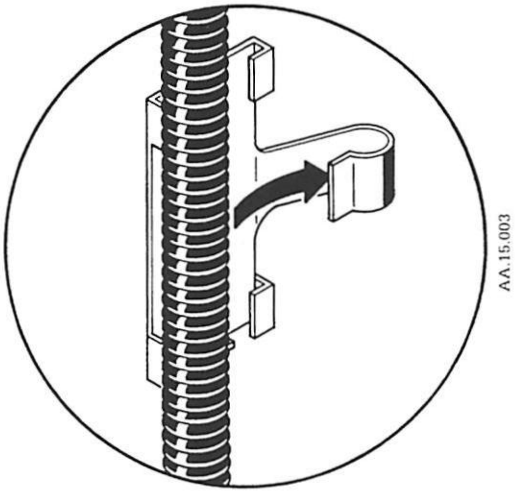


Figure 4-9
The other end of this 17-mm corrugated tube must be connected to the absorber interface manifold's 17-mm, barbed connector.

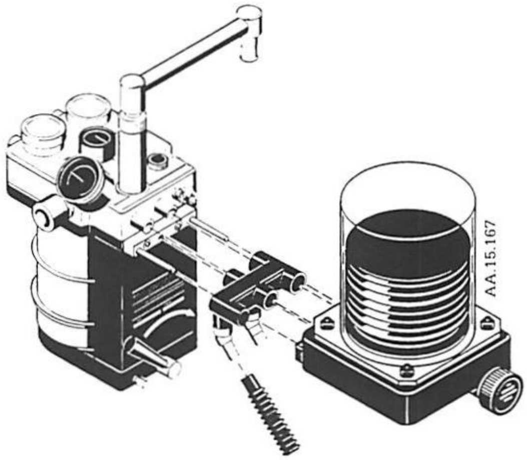


Figure 4-10
One end of the 19-mm-diameter, corrugated tube must be connected to the absorber interface manifold's 19-mm, barbed connector. The Ohmeda Autoclavable Bellows Assembly (ABA) has a 30 mm exhaust port and requires a 30/19 mm adapter to connect 19 mm hose.

The other end of the tube must be connected to a gas scavenging system.

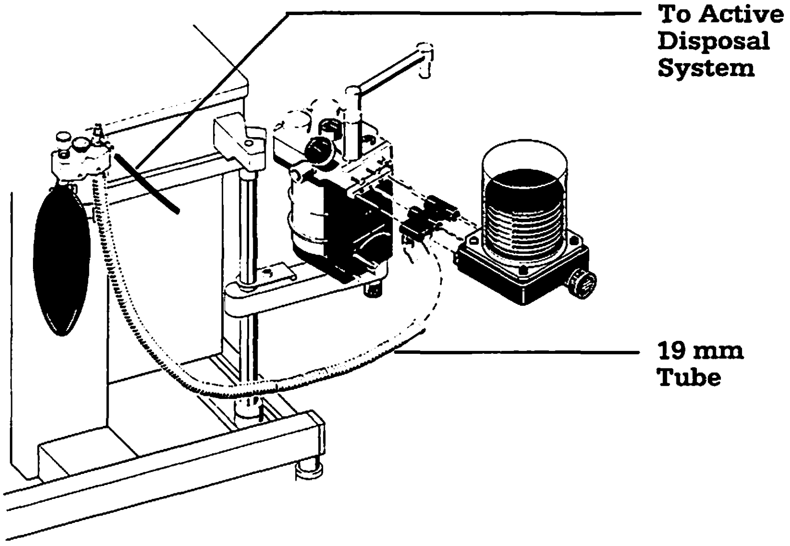
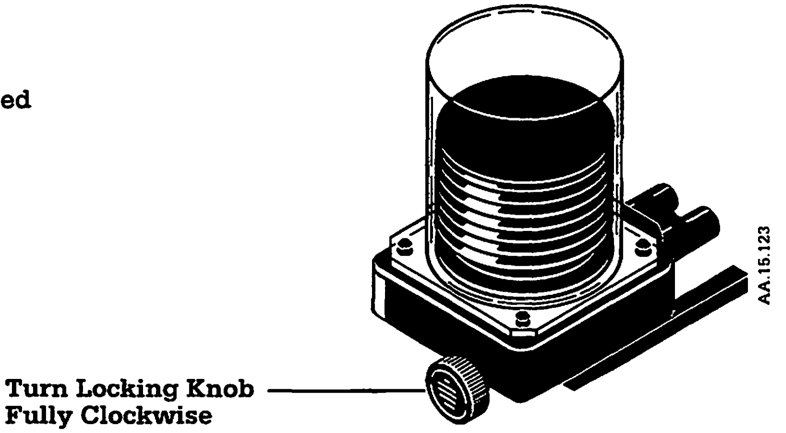


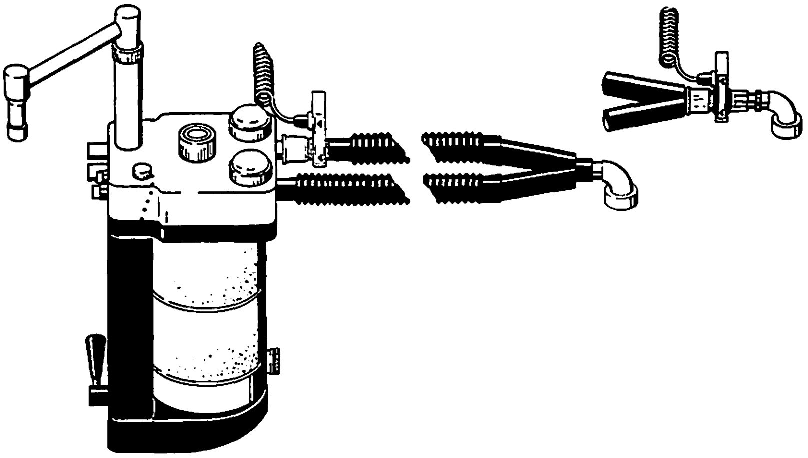
Figure 4-11
The Bellow's Assembly's locking knob must be turned fully clockwise.



4.10 Checking The Monitoring Connections

Before you use the ventilator on a patient, check that all of the monitoring connections are correct and secure.

Figure 4-12
The volume sensor cartridge must be correctly inserted in the breathing system. The cartridge must be clear and free of any obstructions.



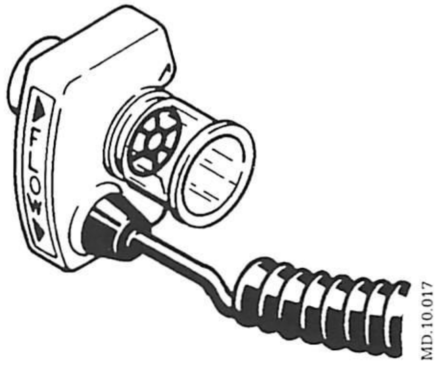

FLOW
MD.10.017

Figure 4-13
The volume sensor clip must be attached to the volume sensor cartridge. The arrows on the clip must point in the direction of gas flow in the breathing system.

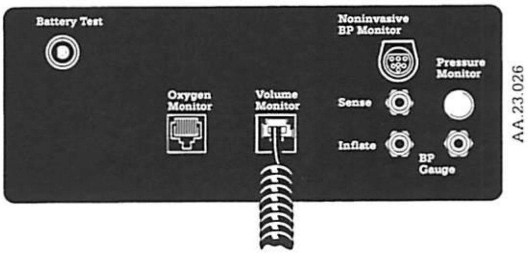

Battery Test
Noninvasive BP Monitor
Pressure Monitor
Oxygen Monitor
Volume Monitor
Sense
Inflate
BP Gauge
AA.23.026

Figure 4-14
The volume sensor clip's electrical cord must be plugged into the receptacle marked "Volume Monitor" on the anesthesia system's patient interface panel. Ensure that the tubing to the volume sensor is draped away from the turbine cartridge to drain possible condensate.

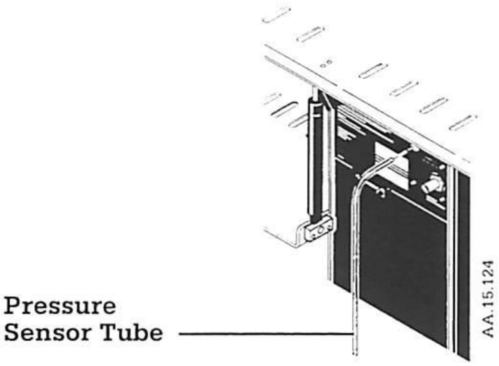

Pressure Sensor Tube
AA.15.124

Figure 4-15
One end of the clear, 3-mm pressure sensor tube must connect to the barbed connector labeled "Connect to Inspiratory Limb of the Breathing Circuit" on the control module's rear panel. This tube must be free of obstructions and kinks.

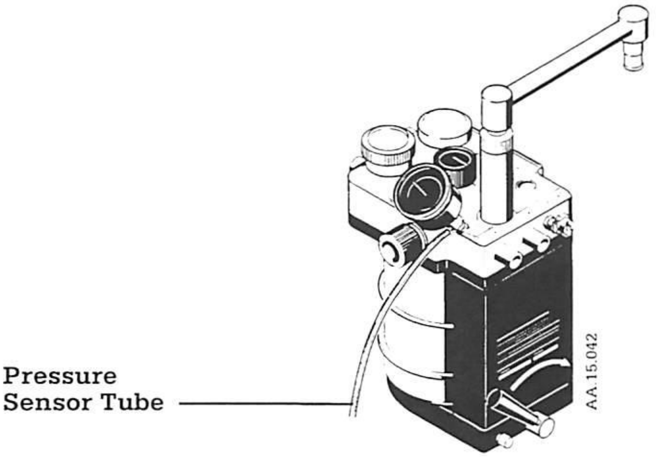
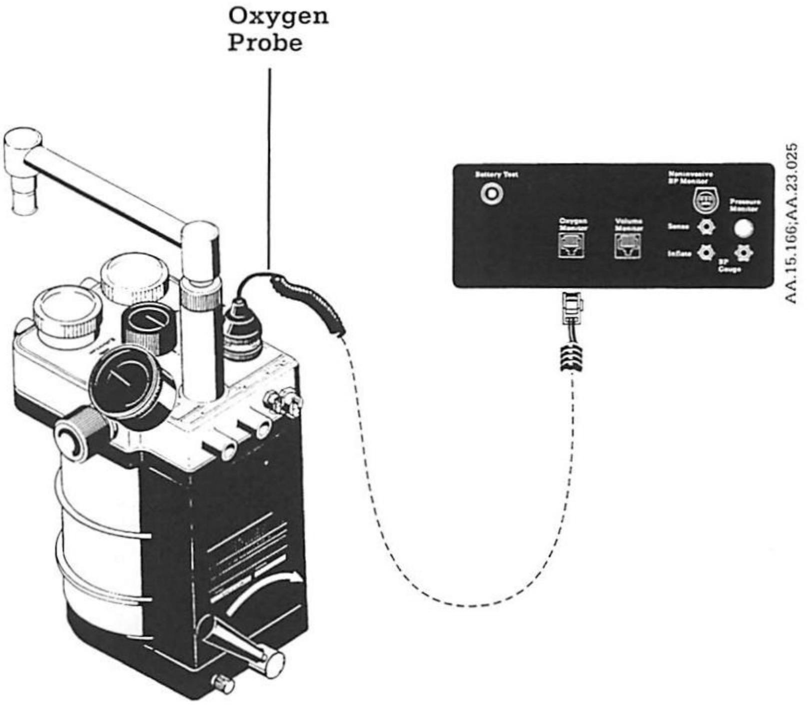

Pressure Sensor Tube
AA.15.042

Figure 4-16
The other end of the pressure sensor tube must connect to the barbed connector mounted under the pressure gauge on the absorber. (If you're using a non-GMS absorber, the tube may connect to an in-line sensing tee in the inspiratory side of the breathing system, as shown in Appendix 9-D.)

Figure 4-17
The oxygen probe's electrical cord must be connected to the receptacle labeled "Oxygen Monitor" on the anesthesia system's patient interface panel. If the probe has been left unplugged, replace the oxygen sensor cartridge. (See section 6.)

The oxygen probe must be in the absorber's oxygen sensor port, which is labeled "Oxygen Sensor." To help prevent leaks, the probe must fit in the port snugly. (If you're using a non-GMS absorber, the probe may be inserted into in-line sensing tee in the inspiratory side of the breathing system, as shown in Appendix 9-D.)



4.11 Testing The Ventilator Alarms

Testing The Low And High Oxygen Alarms

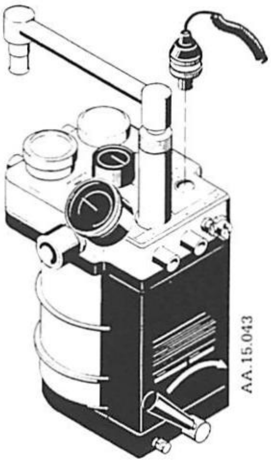
1. Make sure the mechanical ventilation switch is set to OFF.
2. Power ON the system master switch to energize the ventilator.
3. Remove the oxygen sensor probe from the breathing system. Let the sensor sit in room air at least three minutes before you move to the next step.
4. Adjust the O_2 Calibration dial until the O_2 (%) display reads 21 percent. If you can't get a 21% reading, see section 6 and recalibrate.
5. Use the low-O_2 push-wheel to set the Low O_2 alarm limit to 18 percent.

- The ventilator displays: LOW 02 LIMIT = 18%

6. Use the high-O_2 push-wheel to set the High O_2 alarm limit to 40 percent.

- The ventilator displays: HI 02 LIMIT = 40%

Figure 4-18
Removing the oxygen sensor from the breathing system



7. Use the low-O_2 push-wheel to readjust the Low O_2 alarm limit to 22 percent.
- The ventilator displays: LOW O2 LIMIT = 22%
- Within four seconds the ventilator sounds the warble tone, flashes the red LED, and displays the "LOW OXYGEN!" message.
- The ventilator displays: LOW OXYGEN!

8. Now use the low- O_2 push-wheel to readjust the Low O_2 alarm limit to 18 percent.
- The ventilator displays: LOW O2 LIMIT = 18%
- Because you have resolved the alarm condition, the ventilator cancels the Low O_2 alarm within four seconds.

9. Use the high-O_2 push-wheel to readjust the high oxygen alarm limit to 20 percent.
- The ventilator displays: HI O2 LIMIT = 20%
- Within four seconds the ventilator sounds the intermittent tone, flashes the yellow LED, and displays: HIGH OXYGEN!

10. Use the high-O_2 push-wheel to readjust the high oxygen alarm limit to 40 percent.
- The ventilator displays: HI O2 LIMIT = 40%
- The ventilator cancels the high oxygen alarm within four seconds.

11. Return the oxygen sensor probe to the sensing port.

12. At least once a month perform the 100% calibration as described in section 6, Maintaining The System. If you don't know when the sensor was last calibrated, do it now.

Testing The Low Minute Volume, Reverse Flow, And Apnea Alarms

1. Add a breathing bag to the patient circuit at the "Y" connector.
2. Make sure the inspiratory pause is OFF.
3. Set the tidal volume to 500 milliliters.

- The ventilator displays: 500 mL I:E 1:X.X

4. Set the rate to 10 breaths per minute.

- The ventilator displays: 10/min I:E 1:X.X

5. Set the inspiratory flow to 30 liters per minute (I:E = 1:5.0).

- The ventilator displays: I:E = 1:5.0

6. Set the inspiratory pressure limit to 40 cm H_2O.

- The ventilator displays: PMAX=40 SUST=20

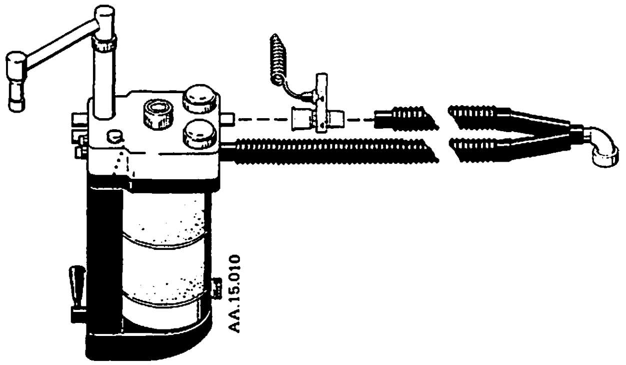


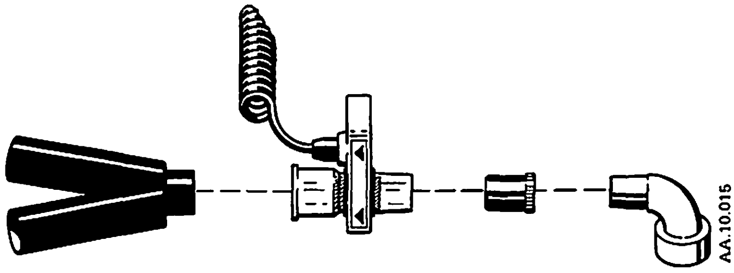
Figure 4-19
Removing the volume sensor cartridge from the absorber, expiratory limb of the patient circuit

7. Use the low $\dot{V}_E$ push-wheel to set the low $\dot{V}_E$ alarm limit to 0.0 liters per minute.

- The ventilator displays: V_E LIMIT = 0.0 L/min

8. Set the anesthesia system's oxygen flow to 2 liters per minute.
9. Ensure that the volume sensor cartridge is in the expiratory limb of the breathing system. Make sure that the arrows on the sensor clip point in the direction of exhaled gas flow.
10. Move the absorber's bag/ventilator switch to "ventilator", if applicable.

Figure 4-20
Removing the volume sensor cartridge from the distal position of the patient circuit



11. Use the anesthesia machine's oxygen flush button to fill the bellows.

Note: Ignore any low pressure alarms that occur while testing the low minute volume, reverse flow and apnea alarms while proceeding with steps 12 through 29.

12. Switch ON mechanical ventilation, then wait 40 seconds. The display $\dot{V}_E$ should be between 3.3 and 4.3 liters per min.

13. Use the low $\dot{V}_E$ pushwheel to readjust the low $\dot{V}_E$ alarm limit to 9.9 liters per minute.
    The ventilator displays: VE LIMIT = 9.9 L
    Then the ventilator sounds the intermittent tone, flashes the yellow LED and displays: LOW MINUTE VOL!

14. Use the low $\dot{V}_E$ pushwheel to set the low $\dot{V}_E$ alarm limit to 0.0 liters per minute.
    The ventilator cancels the low minute volume alarm.

15. Remove the volume-sensor clip from the volume-sensor cartridge.

16. After 30 seconds the ventilator flashes the yellow LED, sounds the warble tone once, and displays: APNEA 31 SEC.
    From this point on the ventilator displays the number of seconds since apnea was detected.

17. In 30 more seconds the tone warbles twice and the ventilator displays: APNEA 60 SEC.

18. Thirty seconds later the tone warbles three times and the ventilator displays: APNEA 90 SEC.

19. Wait until the ventilator displays APNEA 120 SEC.
    The tone warbles continuously, the ventilator flashes the red LED, and the ventilator displays: APNEA **

20. Push the alarm silence button 🔇. The ventilator silences the audio alarm and holds the red LED ON.

21. Put the volume sensor clip back on the volume cartridge. Make sure the arrows point in the direction of exhaled gas flow.

22. After one more ventilation cycle the ventilator clears the apnea alarm and extinguishes the red LED

23. Move the mechanical ventilation switch to OFF.

24. Use the setup page to verify the reverse flow detection is enabled. If reverse flow detection is OFF, switch it ON.

25. Remove the volume sensor clip from the volume cartridge.

26. Reinstall the volume sensor clip backwards (so the arrows point in the opposite direction of the exhaled gas flow) on the volume cartridge.

27. Switch ON mechanical ventilation.
    The ventilator sounds a continuous tone, flashes the yellow LED, and displays: REVERSE FLOW!

28. Correctly reinstall the volume sensor clip on the volume cartridge. Make sure the arrows point in the direction of exhaled gas flow.
    After two ventilation cycles the ventilator clears the reverse flow alarm.

29. Move the mechanical ventilation switch to OFF.

Testing The High, Low, And Sustained Pressure Alarms

1. Make sure the inspiratory pause is OFF.

2. Set the tidal volume to 500 milliliters.

- The ventilator displays: 500 mL I:E 1:X.X

3. Set the rate to 10 breaths per minute.

- The ventilator displays: 10/min I:E 1:X.X

4 Set the inspiratory flow to 30 liters per minute (I:E = 1:5.0).

- The ventilator displays: I:E = 1:5.0

5. Set the inspiratory pressure limit to 40 cm H_2O.

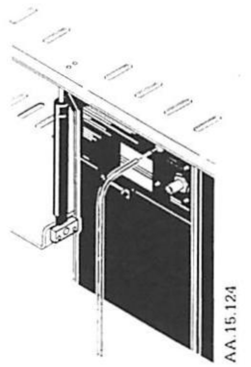
- The ventilator displays: PMAX=40 SUST=20

6. Set the anesthesia machine's oxygen flow to 2 liters per minute.

7. Make sure the pressure sensing tube is securely connected between the control module's connector marked "Connect to Inspiratory Limb of the Breathing Circuit" and the distal-sensing tee on the inspiratory side of the breathing system. (See figures

4-15 and 4-16.) This tee is the barbed connector mounted under the pressure gauge on the absorber. If you're using a device other than an Ohmeda GMS Absorber, the tube may connect to an in-line sensing tee in the inspiratory side of the patient breathing system, as shown in Appendix 9-D.

Figure 4-21
Pressure sensing tube's connection to the control module



8. Move the absorber's Bag/APL-Ventilator switch to "Ventilator."
9. Connect the common gas outlet to the absorber.
10. Open the breathing system at the "Y" connector. (See figure 4-17.)
11. Move the mechanical ventilation switch to ON. After 20 seconds of mechanical ventilation, the ventilator sounds the warble tone once, flashes the red LED, and displays: `LOW PRESSURE!`
12. Move the mechanical ventilation switch to OFF. Within five seconds the ventilator cancels the low pressure alarm and extinguishes the red LED.

Figure 4-22
Pressure sensing tube's connection to the breathing system

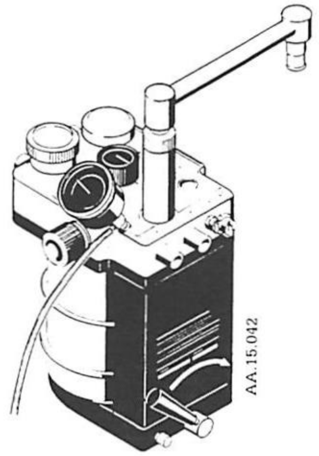
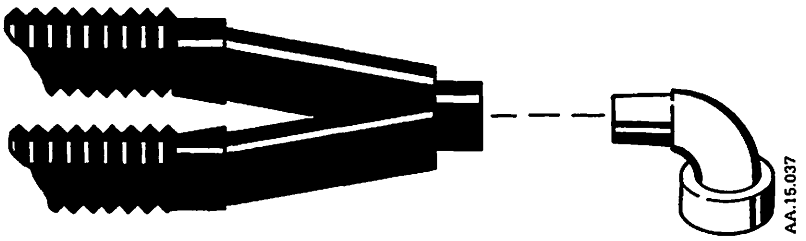


Figure 4-23
Opening the patient circuit at the "Y" connector

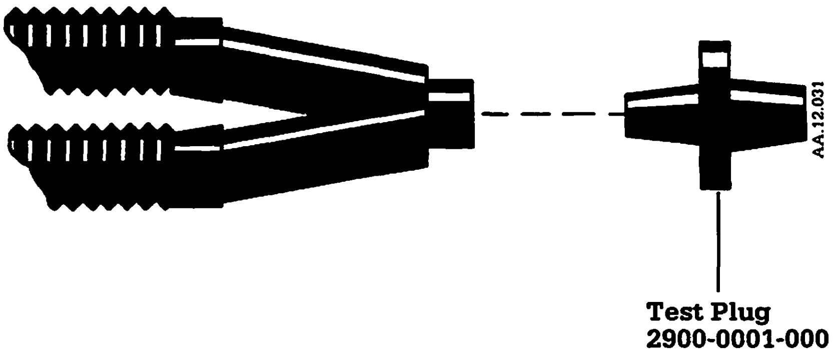


13. Occlude the patient end of the "Y" connector. (See figure 4-18.)

14. Wait for the bellows to inflate. When the bellows are completely extended, move the mechanical ventilation switch to ON. Within ten seconds the ventilator warbles once, flashes the red LED, and displays: HIGH PRESSURE!

WARNING: When occluding the breathing system for test purposes use the Ohmeda Test Plug (2900-0001-000). Do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing-system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for foreign objects.

Figure 4-24
Occluding the patient circuit at the "Y" connector



15. Move the mechanical ventilation switch to OFF. Within ten seconds the ventilator clears the high pressure alarm and extinguishes the red LED.

16. Turn the APL valve fully clockwise.

17. If not already connected, connect a three-liter bag to the bag arm.

18. Move the Bag/APL-Ventilator switch to "Bag/APL." (Maintain the occlusion in the breathing system.)

19. As you press the anesthesia system's oxygen flush button, watch the absorber's pressure gauge until the system pressure reaches at least 20 cm H_2O. Release the flush button and wait 15 seconds

more. Because the pressure still exceeds 20 cm H_2O, the ventilator now sounds the warble tone continuously, lights the red LED, and displays:

SUSTAINED PRES!

20. Slowly open the APL valve to release the pressure in the system. The ventilator silences the sustained pressure alarm when the pressure falls below 20 cm H_2O and extinguishes the red LED.

21. Remove the occlusion from the "Y" connector.

22. Set the "Bag/APL-Ventilator" switch to the position you plan to use.

WARNING: After completing the preoperative checkout procedures, and before starting any procedure during which this device will be used, confirm that all hoses, tubing, and other circuit components are connected properly. Failure to do so may result in patient injury. Refer to the operations manuals for all devices in the system to confirm that they are set up properly.

Notes:

5/Operating the System

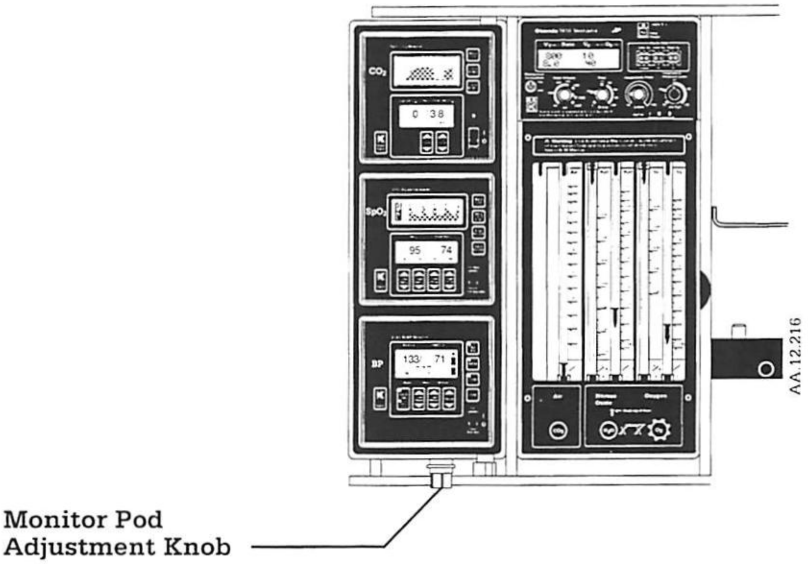
5.1 Preparing The System For Operation

Adjusting The Monitor Pod Viewing Angle

To adjust the monitor pod viewing angle:

1. Loosen the knob located beneath the monitor pod.
2. Adjust the pod to the desired viewing angle.
3. Tighten the knob to secure the pod.

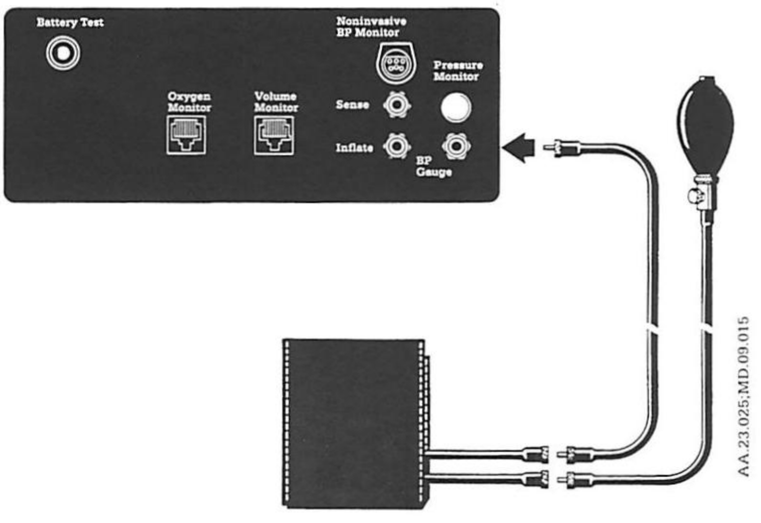
Figure 5-1
Adjusting the monitor pod's viewing angle


CO2
0 38
SpO2
95 74
BP
133/ 71
Monitor Pod Adjustment Knob
AA.12.216

Connecting The Optional Manual Blood Pressure Gauge Inflation System

If your system has an optional manual blood pressure gauge installed, insert the blood-pressure cuff connector into the receptacle labeled "BP Gauge" on the patient interface panel.

Figure 5-2
Optional manual blood pressure gauge inflation system


Battery Test
Noninvasive BP Monitor
Pressure Monitor
Oxygen Monitor
Volume Monitor
Sense
Inflate
BP Gauge
AA.23.025;MD.09.015

5.2 Filling And Draining The Ohmeda Vaporizers

WARNING: Do not fill the vaporizer with any agent other than that which is specified on the front label. The vaporizer is designed for that agent only. Using any other agent can cause injury to the patient.

WARNING: Do not fill the vaporizer unless the control dial is in the OFF position.

WARNING: Do not turn the control dial ON during filling or attempt to fill beyond the ⊼ fill mark

WARNING: Do not drain the agent into any container other than a properly marked drug container. Discard the old agent in a manner consistent with local policies and guidelines, as well as good environmental practices.

General

Periodically check the agent level of the vaporizer. The vaporizer should be filled when the agent level gets near the low level ⊻ mark. As long as the agent is visible above the low level mark, the vaporizer should function according the specifications. For complete instructions on using the vaporizers, refer to the Ohmeda.

Tec 6 Continuous Flow Vaporizer operators manual, stock number 1107-0102-000.

Tec 5 Continuous Flow Vaporizer operators manual, stock number 1105-0100-000.

Tec 4 Continuous Flow Vaporizer operators manual, stock number 0205-7106-300.

The vaporizer should be filled and used in an upright position. Small deviations from the upright position will not affect the output or the safety of the vaporizer. But, because the agent depth is shallow in relation to the diameter of the vaporizing chamber, more frequent checks must be made when small deviations from the upright position occur. This avoids a misleading impression about the amount of agent in the chamber.

At least every two weeks and whenever the agent is low, drain the vaporizer agent into a correctly labeled drug bottle. This helps preserve the drug purity by removing the old agent with oxidized impurities, accumulated contaminants and stabilizers. Discard the old agent in a manner consistent with local policies and guidelines. Less frequent draining intervals may be used if the anesthetic agent does not contain additives or stabilizing agents.

5.3 Powering The System ON

A two-position system master switch to the right of the pressure gauges, controls electrical and pneumatic power to the system. When the switch is in its first position, both electrical and pneumatic power are OFF. In the second position, both electrical and pneumatic power are ON.

Just left of the switch is the system's indicator panel, which provides information about the status of the system's electrical supply, battery condition and oxygen supply.

When the switch is set to OFF the panel's indicator lights are OFF; gas is not supplied to the flow-control circuits; electrical power is not supplied to the monitors or ventilator; but a-c power is provided to the a-c outlets on the back of the anesthesia machine.

When the switch is set to ON: the "Normal" indicator is lighted; gas is supplied to the machine's circuits; and electrical power is provided to the monitors.

If the switch is set to ON and the anesthesia machine's d-c power supply fails, either because of an electronic failure or because the anesthesia system's a-c power is lost, the "Mains" indicator goes out and the "Battery" indicator lights. When the "Battery" indicator is lighted, the system is powered by its built-in backup battery, which is designed to temporarily provide power allowing the ventilator and its integrated oxygen, volume and airway-pressure monitors to continue operating.

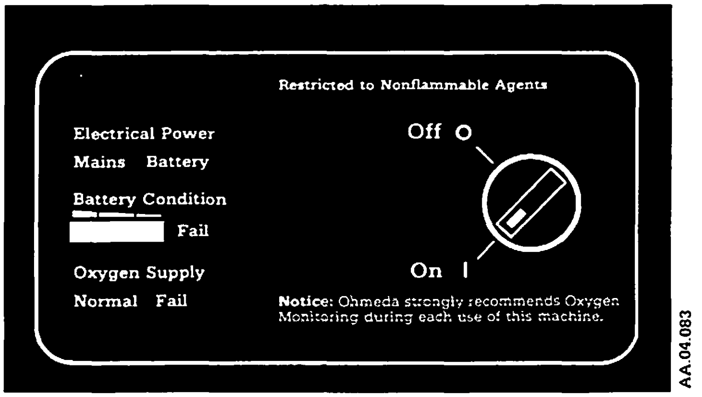

Restricted to Nonflammable Agents
Electrical Power
Mains Battery
Battery Condition
Fail
Oxygen Supply
Normal Fail
Off O
On I
Notice: Ohmeda strongly recommends Oxygen Monitoring during each use of this machine.
AA.04.083

Figure 5-3
System master switch

---

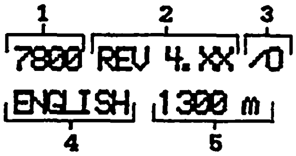
1. Turn all the gas flow control knobs completely clockwise.
2. Set the vaporizers to OFF.
3. Move the mechanical ventilation switch to OFF.
4. Move the system master switch to ON.
5. Perform the preoperative checkout procedures.

5.4 Setting the reverse flow alarm, sigh, contrast, audio volume

Parameters set in the setup page are retained when the ventilator is turned OFF.

To set the altitude compensation

1. Move the mechanical ventilation switch to OFF.
2. Turn the system ON/OFF switch to ON.
3. Press and continue to hold down the alarm silence button, 🔕, then press in the inspiratory pause button. Release both buttons. The ventilator displays:



1 meter (3.28 feet)

1. Ventilator Model
2. Software Version
3. Ventilator Drive Gas (A=Air; O=O2; E=Error)
4. Language
5. Altitude

WARNING: Pay attention to the information on the setup page. If the model number or drive gas is incorrect, have a trained Ohmeda service representative service the ventilator.

To exit the setup pages at any step, repeatedly press 🔕, do not adjust a control for 30 seconds, or set the mechanical ventilation switch to ON. All previous changes will be saved in the ventilator memory.

4. Press 🔕. The ventilator displays:

    FLOW KNOB TO SET
    REV FLOW ALM ON (or) OFF

Turn the flow knob to switch the alarm selection ON or OFF. If the volume sensor is at the proximal end of the Y, select OFF to disable the alarm. If the volume sensor is at the expiratory port of the absorber, select ON to enable the alarm.

5. Press 🔕. The ventilator displays:

    FLOW KNOB TO SET
    SIGH ON (or) OFF

Turn the flow knob to switch sigh breaths ON or OFF. When sigh is ON, the ventilator delivers one and a half times the tidal volume (up to a maximum 1.5 L) once every 64 breaths.

6. Press 🔕. The ventilator displays:

```
FLOW KNOB TO SET
CONTRAST: xx
```

Turn the flow knob to adjust the ventilator display contrast (XX) from 1 (lowest contrast) to 10 (highest).

7. Press 🔕. A tone sounds and the ventilator displays:

```
FLOW KNOB TO SET
AUDIO VOLUME: xx
```

Turn the flow knob to adjust the ventilator alarm volume (XX) from 1 (lowest) to 10 (highest). Tone volume changes to the selected level.

8. Press 🔕. The ventilator beeps once and displays:

```
CHECK SETTINGS!
```

5.5 Checking the supply gas

⚠

CAUTION: If the supply gas displayed is other than the supply gas you are using ("/O" for oxygen, "/A" for air; "E" for Error), have an Ohmeda trained service representative reset the ventilator. Using a supply gas that does not match the displayed supply gas will result in operational errors.

How to determine your ventilator's drive-gas setting

On the first line of ventilator's setup page a character is displayed that indicates the current supply-gas setting. "O" indicates oxygen and "A" indicates medical-grade air.

Note: To enter the setup page: make sure the mechanical ventilation switch is OFF, press and continue to hold down the alarm silence 🔕 button, press the inspiratory pause button, then release both buttons.

To return to normal operations press the alarm silence 🔕 button to move through the menu or, leave the Setup Page display on without any parameter changes for 30 seconds.

5.6 Setting The Alarm Limits

Use the three alarm-set pushwheels to change the low-minute-volume, low-oxygen, and high-oxygen alarms' set points. To increase the value of an alarm set point, push the button directly over the digit you want to change. To decrease the value, push the button under the digit you are changing. Use the inspiratory pressure to set the inspiratory pressure limit and the sustained pressure limit. To adjust these limits, press the inspiratory pressure limit knob as you turn it.

Anytime you change the value of an alarm set point, the ventilator will display that alarm's value on the screen.

A. To set the alarm limits

1. If the anesthesia system is OFF, move the mechanical ventilation switch to OFF before moving the system master switch to ON.

2. Switch ON the anesthesia system, if it is not ON already.

3. Use the low-$\dot{V}_E$ pushwheel to set the low minute volume alarm limit. The low minute volume alarm limits are zero liters per minute to 9.9 liters per minute in 0.1 L/min. increments.

WARNING: Always correctly set the low minute volume alarm and use CO_2 monitoring to aid in the detection of breathing system disconnections.

4. Use the low-O_2 pushwheel to set the low oxygen alarm limit. The low oxygen alarm limits are 18 percent to 99 percent in one percent increments.

   Although all the digits can be physically set to zero, the ventilator will not accept low oxygen alarm limits of less than 18 percent. If you set the low oxygen alarm pushwheel to less than 18 percent, the ventilator will continue to use 18 percent for the low oxygen alarm's set point; and the ventilator will display a "LIMIT SET ERROR!" message.

5. Use the high-O_2 pushwheel to set the high oxygen alarm's limit. The high oxygen alarm limits are 18 percent to 99 percent in one percent increments.

   If you set the high-O_2 pushwheel to a level below or equal to the limit set by the low-O_2 pushwheel, the ventilator will display a "LIMIT SET ERROR!" message. However, the ventilator will continue to use the level shown on the high-O_2 pushwheel as the high oxygen alarm trigger point.

   To disable the high oxygen alarm, set the high-O_2 pushwheel to "00"; setting the high-O_2 pushwheel to "00" will not generate a "LIMIT SET ERROR!" message.

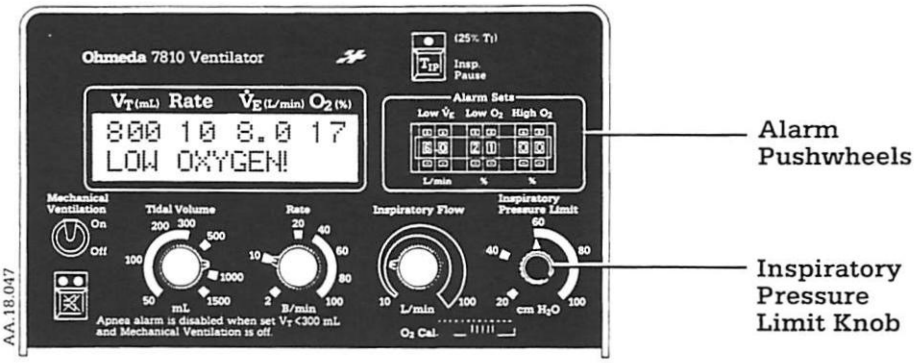
6. Use the inspiratory pressure limit knob to set the inspiratory pressure limit and the sustained pressure limit.

Both the maximum inspiratory pressure and the sustained pressure alarm limits and pressure-release points are set by the inspiratory pressure limit knob, which must be pushed in while being turned to change the settings; the ventilator sets the sustained pressure limit to correspond to the inspiratory pressure limit knob setting. For inspiratory pressure limits of 20 cm H_2O to 60 cm H_2O, the ventilator sets the sustained pressure limit to one half the inspiratory pressure limit. For example, if the inspiratory pressure limit is 42 cm H_2O, the sustained pressure limit will be 21 cm H_2O. However, any inspiratory pressure limit setting higher than 60 cm H_2O will result in a sustained pressure limit of 30 cm H_2O. For example, inspiratory pressure limits of 65 cm H_2O and 80 cm H_2O will both result in a sustained pressure limit of 30 cm H_2O.

As you push and turn the inspiratory pressure limit knob, the ventilator will display both the maximum pressure limit and the sustained pressure limit settings. However, unlike the other three control knobs, just touching this knob will not generate a display.

If, while the mechanical ventilation switch is OFF, you set the inspired pressure limit for more than 60 cm H_2O, the ventilator will beep, light the yellow LED, and continually display the maximum pressure setting. This pressure limit message is displayed in the Monitoring mode only: during mechanical ventilation this reminder is disabled.

Figure 5-4 The alarm pushwheels and inspiratory pressure limit knob


Ohmeda 7810 Ventilator
(25% T_I)
T_{IP}
Insp. Pause
V_T (mL) Rate $\dot{V}_E$ (L/min) O_2 (%)
800 10 8.0 17
LOW OXYGEN!
Alarm Sets
Low $\dot{V}_E$
Low O_2
High O_2
L/min
%
%
Mechanical Ventilation
On
Off
Tidal Volume
50
100
200
300
500
1000
1500
mL
Rate
2
10
20
40
60
80
100
B/min
Inspiratory Flow
10
100
L/min
Inspiratory Pressure Limit
20
40
60
80
100
cm H_2O
Apnea alarm is disabled when set V_T <300 mL and Mechanical Ventilation is off.
O_2 Cal.
AA.18.047
Alarm Pushwheels
Inspiratory Pressure Limit Knob

In addition to the three alarms set by the pushwheels and the two alarms set by the inspiratory pressure limit knob, the ventilator also sets trigger points for certain alarms based on the positions of other front panel controls. These alarms include the low pressure alarm, the apnea alarm, and the reverse flow alarm.

B. Low Pressure Alarm

The low pressure alarm activates if the airway pressure fails to change by a value the ventilator sets. This level of change depends on the settings of the tidal volume knob and the inspiratory flow knob.

The ventilator generates a low pressure alarm if the airway pressure fails to change by a value that varies proportionally to the setting of the inspiratory flow knob. The amount of change required to prevent an alarm from triggering will vary between 4 cm H_2O to 9 cm H_2O to correspond to the inspiratory flow range of 10 liters per minute to 100 liters per minute. For example, if the inspiratory flow is set to 30 liters per minute, the low pressure alarm will activate if the pressure doesn't change by at least 5.1 cm H_2O. But if the inspiratory flow is set to 80 L/min., the change must be at least 7.9 cm H_2O to keep the alarm from activating.

Unlike the other alarms, the low pressure alarm is active only when mechanical ventilation is switched ON.

C. Apnea Alarm

The apnea alarm is keyed to the tidal volume knob's setting and the position of the mechanical ventilation switch. When the tidal volume knob is set to less than 300 mL and the mechanical ventilation switch is OFF, the apnea alarm is disabled. If you have set the front panel controls to disable the apnea alarm, the ventilator alerts you by constantly displaying the "APNEA ALARM OFF!" message. To enable the apnea alarm when in the Monitoring mode, set the tidal volume knob to 300 mL or more.

D. Reverse Flow Alarm

The reverse flow alarm is tied to the tidal volume level regardless of the mechanical ventilation switch's position. If the tidal volume knob is set to 300 mL or more, an alarm will activate if the ventilator senses 100 mL or more reverse flow. If the tidal volume knob is set to no less than 300 mL, then 20 mL or more reverse flow will trigger the alarm.

WARNING: The reverse flow alarm will function correctly only if the volume sensor cartridge is working correctly and is properly placed in the distal position of the expiratory limb of the breathing system.

5.7 Setting The Gas Flow

Each gas included on your anesthesia machine is controlled by a single flow control valve. These flow control valves, which are above the pressure gauges and below the flowmeters, are marked with the symbols for the gases they control, and are color coded to match the backgrounds of the corresponding pressure gauges and flowmeters. So that you can identify it by touch, the knob for oxygen is fluted. The knobs for nitrous oxide and, when included, a third gas are etched with a finer, cross-hatch pattern.

The Ohmeda Link Control connects the oxygen and nitrous oxide flow control valves. This system is designed both to ensure that any oxygen/nitrous oxide mixture includes a minimum of about 30 percent oxygen, and to help prevent the oxygen flow from dropping below 200 mL/min..

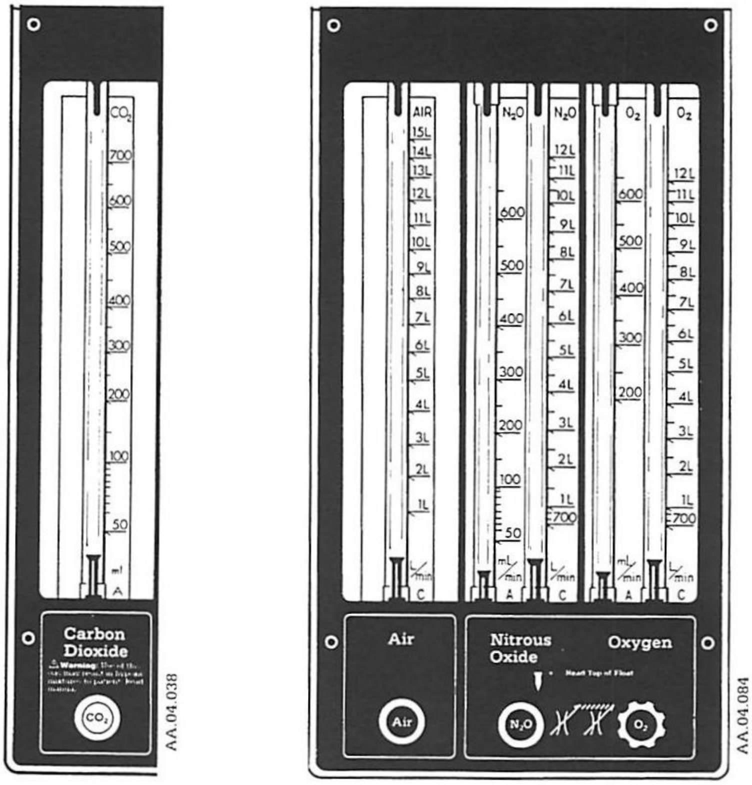
WARNING: The Ohmeda Link Control ensures only that oxygen/nitrous oxide mixtures will have a minimum (nominal 30 percent) oxygen concentration. Hypoxic mixtures may be delivered if gases other than oxygen, nitrous oxide and/or air are used, or when operating at low oxygen flow rates.

Flowmeters for each gas included in your system are mounted directly above the corresponding flow control valves. The backgrounds of these flowmeters are color coded to match the pressure gauges and control valves. When you are using a flowmeter, read across the top of the meter's float, which is inside the flowmeter's tube, the scale to the immediate right of the float.

To set the gas flow:

1. Close the flow controls. Set the system master switch to ON.
2. Turn the control knob for the gas whose level you want to set. Read across the top of the flowmeter's floats.

Figure 5-5 The flow control knobs and flowmeters



CO₂
700
600
500
400
300
200
100
50
ml A
Carbon Dioxide
CO₂
AA.04.038
AIR
15L
14L
13L
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
L/min C
N₂O
600
500
400
300
200
100
50
ml/min A
N₂O
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
700
L/min C
O₂
600
500
400
300
200
ml/min A
O₂
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
700
L/min C
Air
Nitrous Oxide
Oxygen
Air
N₂O
O₂
AA.04.084

5.8 Setting The Vaporizers

For complete instructions on using the vaporizers, refer to the Ohmeda Tec 4, Tec 5, or Tec 6 Continuous Flow Vaporizer Operators Manual.

1. Check that the vaporizers are securely installed.
2. Check the agent level shown in the vaporizer's sight glass. If the agent is below the fill line, fill the vaporizer.
3. Set the carrier gas flow.
4. Press the vaporizer's control-release button and turn the dial to the setting you want to use.

Figure 5-6
Vaporizer controls

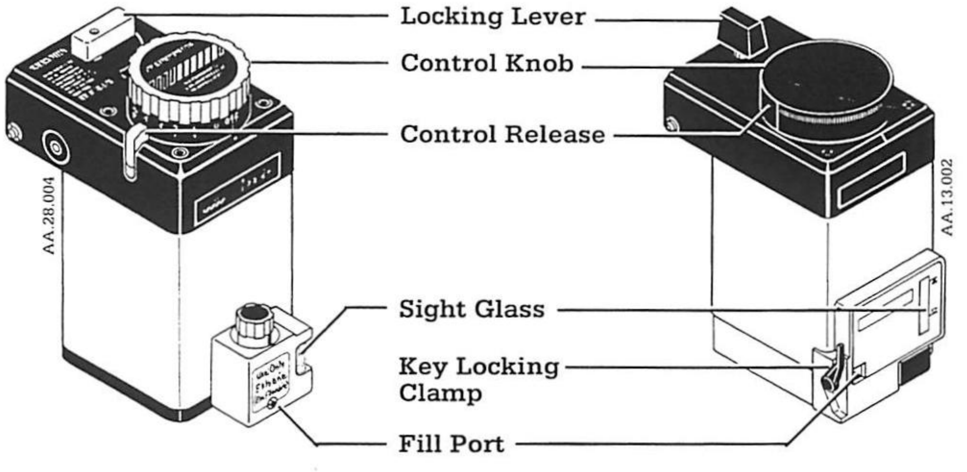
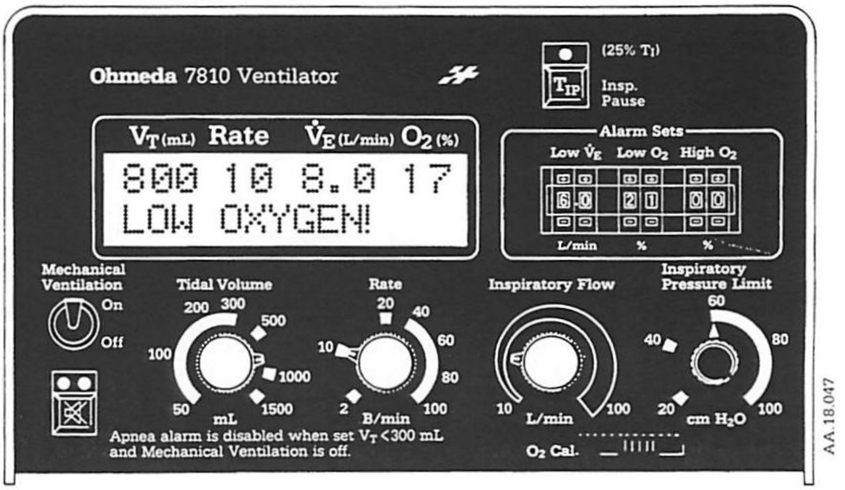

Locking Lever
Control Knob
Control Release
Sight Glass
Key Locking Clamp
Fill Port
AA.28.004
AA.13.002

Figure 5-7 The control module's front panel


Ohmeda 7810 Ventilator
(25% TI)
TIP
Insp. Pause
VT (mL) Rate V̇E (L/min) O2 (%)
800 10 8.0 17
LOW OXYGEN!
Alarm Sets
Low V̇E Low O2 High O2
6.0 21 00
L/min % %
Mechanical Ventilation
On
Off
Tidal Volume
50 100 200 300 500 1000 1500
mL
Rate
2 10 20 40 60 80 100
B/min
Inspiratory Flow
10 100
L/min
Inspiratory Pressure Limit
20 40 60 80 100
cm H2O
Apnea alarm is disabled when set VT <300 mL and Mechanical Ventilation is off.
O2 Cal.
AA.18.047

5.9 Setting The Ventilation Parameters, Beginning Ventilation

Set the ventilation parameters before moving the mechanical ventilation switch to ON. Because we recommend that you set the ventilator's controls starting on the left and moving to the right, these instructions describe setting the ventilator's controls from left to right. You can, however, adjust the front panel knobs in any order and independently. If you do adjust either the tidal volume knob or rate knob without also adjusting the inspiratory flow knob, touch the inspiratory flow knob to check the new I:E ratio.

It is possible to adjust the controls for a combination of settings that will result in a level the ventilator cannot deliver. If the combination of settings results in a level the ventilator is not designed to deliver, a "VENT SET ERROR!" alarm will be displayed.

The measured tidal volume indicated on the screen may be different than the level you set on the tidal volume knob. Under pressure gases compress and certain breathing system components expand, which results in some loss of tidal volume in the breathing system. Also, any fresh gas introduced to the system will be measured by the volume sensor in addition to the gas the bellows assembly delivers.

You don't, however, have to manually calculate the compliance effect to compensate for compliance losses. With the volume sensor correctly connected in the breathing system, adjust the tidal volume knob until the tidal volume reading on the ventilator's screen indicates the level you want to use.

Set the ventilation parameters and begin mechanical ventilation

1. Begin connecting the ventilator to a patient, perform the Preoperative Checkout Procedures.
2. Move the mechanical ventilation switch to OFF before switching ON the anesthesia system's electrical power.
3. Switch ON the anesthesia system, if it is not ON already.

The ventilator enters the Monitoring mode. Because the monitoring is active whenever the anesthesia system's power is ON, some alarms may sound. To silence any alarms, press Alarm Silence.

4. Set the alarm limits.
5. While the mechanical ventilation switch is OFF, use the tidal volume knob to set the tidal volume.

The tidal volume knob lets you set the tidal volume from 50 milliliters to 1500 milliliters. As you turn the knob, the ventilator will display the tidal volume setting. To check the tidal volume setting without changing its value, just touch the knob; the ventilator will then display the current tidal volume setting. Until the ventilator senses sufficient volume to indicate a breath, it will display "VOL MON STANDBY!" Once the ventilator senses a sufficient volume level, it will remove the "VOL MON STANDBY!" message and start the timer that controls the apnea alarm. If, however, while the mechanical ventilation switch is OFF, you set the tidal volume to less than 300 mL, the ventilator will disable the apnea alarm. Once the ventilator removes the "VOL MON STANDBY!" message--after an activation breath--the ventilator will display the "APNEA ALARM OFF!" message. If you want the apnea alarm enabled when the ventilator is in the Monitoring mode, set the tidal volume knob to 300 mL or higher.

6. Use the rate knob to set the mechanical breath rate.

Turning the rate knob changes the breath rate used for mechanical ventilation and displays the rate. The rate's range is two breaths per minute to 100 breaths per minute in whole number increments. Touching the rate knob will display the current rate on the screen.

7. Use the inspiratory flow knob to set the inspiratory flow rate.

The inspiratory flow knob lets you set the inspiratory flow rate, which is continuously variable from 10 liters per minute to 100 liters per minute. Whenever you adjust or just touch the inspiratory flow knob, the ventilator will display the current I:E ratio, which the ventilator calculates base on the set inspiratory flow, tidal volume and breath rate. Adjusting any of these parameters will change the I:E ratio; to check the current I:E ratio, touch the inspiratory flow knob.

8. Move the absorber's Bag/APL-Ventilator switch to "Ventilator."

9. Use the anesthesia system's oxygen flush valve to fill the bellows. Set the oxygen flow to a level that keeps the bellows fully extended.

10. To start mechanical ventilation, move the mechanical ventilation switch to ON.

The mechanical ventilation switch controls mechanical vent only. When the switch is OFF, the monitors still function and the alarm system is still active. When you want to start mechanical ventilation, move the switch to ON.

Always switch ON the anesthesia system and set the control module's front panel controls before switching ON the ventilator. Switching ON the ventilator before setting the controls may result in inappropriate ventilation of the patient and may trip alarms that relate to mechanical ventilation.

11. Once the ventilator is mechanically ventilating the patient, check the tidal volume. If necessary, adjust the front panel controls to modify the ventilator's operating parameters. You can adjust any of the front panel controls while the ventilator is ON.

5.10 Responding To Alarms

These sections describe the alarms and alarm messages the system may display. Although we have provided recommendations on how to resolve messages directly related to the system's operation, only the clinician can determine what to do when an alarm relates to the patient's condition. The first step when any alarm sounds is to check the patient. Then, to resolve the alarm, follow the steps listed below.

WARNING: If an alarm condition cannot be resolved, do not continue to use the system.

A. Responding To Anesthesia Machine Alarms

Responding to an electrical disconnect/failure alarm

If the anesthesia machine's AC power supply fails or is disconnected, the system will sound a warbling, intermittent alarm and will flash the "Battery" indicator to the left of the master switch. If AC power is lost, the system's built-in backup battery will temporarily provide power to provide backup power to the ventilator and its integrated oxygen, volume, and circuit-pressure monitors. The battery, however, will not power any equipment plugged into the electrical pod outlets, the light panel, the Record Keeper (if installed), or optional monitors.

If the Electrical Disconnect/Failure Alarm activates:

1. Continue normal operation; the backup battery will allow you to continue for about another hour with mechanical ventilation.
2. Make sure the system power cord has not been disconnected.
3. Resolve the cause of the power failure.

Responding to an oxygen supply failure alarm

If the oxygen supply pressure drops below 193 kPa (28 psig.), the system will sound the oxygen supply alarm continuously and flash the oxygen supply "Fail" indicator. If oxygen pressure then drops below 138 kPa (20 psig.), the system will shut off the nitrous oxide and air supplies. The oxygen supply failure alarm also will sound briefly when you switch ON the system.

If the oxygen supply failure alarm sounds:

1. Open the reserve oxygen cylinder.
2. Switch OFF mechanical ventilation until the oxygen supply is restored.
3. Switch to the Bag/APL mode and use manual ventilation.
4. Check the oxygen pipeline gauge.
5. Check the oxygen pipeline for disconnections.

B. Responding To Ventilator Alarms

Responding to an APNEA xxx SEC. Message

If for 30 seconds the ventilator doesn't detect enough volume in the breathing system, and apnea alarm will be generated. The alarm message will indicate the number of seconds that have passed since flow was last detected. The tone will warble once at 30 seconds, twice at 60 seconds, and three times at 90 seconds. At 120 seconds the tone will warble continuously and the screen will display "APNEA **" only.

The ventilator uses the volume-sensing circuits to activate the apnea alarm. When the ventilator is first switched ON it displays the "VOL MON STANDBY!" message to indicate that the apnea and low minute volume alarms are not enabled. Then, once the ventilator senses a sufficient volume level, it removes the "VOL MON STANDBY!" message and starts a timer that controls the apnea alarm. Each time the ventilator senses sufficient volume, it resets this apnea timer.

The actual volume threshold required to start or reset the apnea timer varies depending on the level you set on the tidal volume knob. For tidal volume settings between 180 mL and 400 mL, the threshold varies linearly from 20 mL to 100 mL. for tidal volume settings below 180 mL, the threshold is always 20 mL. And for tidal volume settings above 400 mL, the threshold is always 100 mL.

For example, if the tidal volume knob is set to 250 mL, and mechanical ventilation is switched ON, the timer starts and is reset when the ventilator senses a breath of at least 46 mL. If you then increase the tidal volume knob to 320 mL, the ventilator will increase the threshold to 71 mL. In either case, if the timer reaches 30 seconds (because the ventilator didn't sense enough volume to indicate a breath), the first in the series of four apnea alarms will sound.

Since the ventilator uses the volume-sensing circuits to determine if an apnea condition exists, problems with the volume sensor cartridge or clip can trigger an apnea alarm, as can disconnections in the breathing system.

⚠ **WARNING: If you remove the sensor clip from the volume sensor cartridge before switching ON the anesthesia system, the apnea alarms will be inoperative. Do not use the ventilator without the sensor clip properly attached to the volume sensor cartridge.**

If the apnea alarm activates:

1. Check the patient.
2. Check for disconnections in the patient breathing system.
3. Check for excessive moisture in the volume sensor cartridge.
4. Check for excessive moisture in the absorber's check valves.
5. Make sure the volume sensor clip is connected securely to the volume sensor cartridge.

6. Make sure the arrows on the volume sensor clip point toward the absorber.

7. Make sure the volume sensor clip is plugged into the anesthesia system's patient interface panel.

8. Replace the volume sensor cartridge. It may be worn out if its rotor is turning too slowly or not at all.

9. Replace the volume sensor clip.

Responding to a LOW OXYGEN ! Message

If the ventilator detects an oxygen concentration lower than the one you set using the low-O_2 pushwheel, the ventilator will generate a low oxygen alarm.

If a low oxygen alarm activates:

1. Check the patient.

2. Check the anesthesia system's flowmeter settings. Are they set correctly?

3. Check the anesthesia system's pressure gauges.

4. Check the low-O_2 alarm limit. Is it set correctly?

5. Check the oxygen supply.

6. Check the oxygen sensor assembly for damage.

7. Make sure the oxygen sensor is inserted securely into the absorber oxygen port.

8. Make sure the oxygen sensor is plugged into the anesthesia system's patient interface panel.

9. Check the oxygen-sensor cartridge's surface for excessive moisture.

10. Has the oxygen sensor been left unplugged from the patient interface panel? If it has, or if the control module has been left disconnected from the panel, replace the oxygen sensor. See section 6 for possible restoration .

11. Replace the oxygen-sensor cartridge. It may be worn out.

Responding to a HIGH OXYGEN ! Message

If the ventilator detects an oxygen concentration equal to or higher than the one you set using the high-O_2 pushwheel, the ventilator will generate a high oxygen alarm.

If the high oxygen alarm activates:

1. Check the high-O_2 alarm limit. Is it set correctly?

2. Check the anesthesia system settings.

3. Has the oxygen sensor been left unplugged from the patient interface panel? If it has, or if the control module has been left disconnected from the panel, an oxide coating may have built up on the sensor's surface. Connecting the sensor through the patient interface panel to the control module will eventually remove this coating. However, up to 12 hours may be required to free the sensor's surface of oxide build-up.

Responding to a
HIGH PRESSURE !
Message

If, during mechanical ventilation or while in the Monitoring mode, the ventilator detects airway pressure higher than the limit you set using the inspiratory pressure limit knob, the ventilator will generate a high pressure alarm. And, during mechanical ventilation only, the ventilator will also terminate the inspiratory cycle.

If the high pressure alarm activates:

1. Check the patient.
2. Check for a blockage in the patient breathing system.
3. Check the inspiratory pressure limit knob. Is it set correctly?
4. Check for moisture in the sensing line that connects the absorber to the ventilator's control module.
5. Check for kinks in the pressure sensing line.

Responding to a
LOW PRESSURE !
Message

The ventilator generates a low pressure alarm if, for at least 20 seconds, the airway pressure fails to change by a value that varies proportionally to the setting of the inspiratory flow knob. The amount of change required to prevent an alarm from triggering will vary between 4 cm H_2O to 9 cm H_2O to correspond to the inspiratory flow range of 10 liters per minute to 100 liters per minute. For example, if the inspiratory flow is set to 30 L/min., the low pressure alarm will activate if the pressure doesn't change by at least 5.1 cm H_2O. But if the inspiratory flow is set to 80 L/min., the change must be at least 7.9 cm H_2O to keep the alarm from activating.

Unlike other alarms, the low pressure alarm is active only when mechanical ventilation is switched ON.

If the low pressure alarm activates:

1. Check the patient.
2. Check the breathing system for leaks or disconnections.
3. Check for leaks or disconnections in the sensing tube that connects the absorber to the barbed connector on the control module's rear panel.
4. Check for kinks in the pressure-sensing line.
5. Is the patient breathing spontaneously? During mechanical ventilation, spontaneous breathing may trip this alarm.

Responding to a SUSTAINED PRES ! Message

The ventilator sets the sustained pressure limit to correspond to the inspiratory pressure limit knob setting. For inspiratory pressure limits of 20 cm H_2O to 60 cm H_2O, the ventilator sets the sustained pressure limit to one half the inspiratory pressure limit. For example, if the inspiratory pressure limit is 42 cm H_2O, the sustained pressure limit will be 21 cm H_2O. However, any inspiratory pressure limit setting higher than 60 cm H_2O will result in a sustained pressure limit of 30 cm H_2O. For example, inspiratory pressure limits of 65 cm H_2O and 80 cm H_2O will both result in a sustained pressure limit of 30 cm H_2O.

Anytime the airway pressure exceeds--for 15 seconds or more--the sustained pressure limit set by the inspiratory pressure limit knob, the ventilator will generate a sustained pressure alarm.

If the Sustained Pressure alarm activates:

1. Check the patient.
2. Check for kinks or blockages in the breathing tubes.
3. Check to make sure the absorber's Bag/APL-Ventilator Valve is in the correct position.

Responding to a SUB-ATMOS. PRES ! Message

If the ventilator detects airway pressure of less than -10 cm H_2O, it will generate a sub atmospheric pressure alarm. For example, airway pressure of -12 cm H_2O will cause an alarm.

If the Subatmospheric Pressure alarm activates:

1. Check for inadvertent vacuum hook-ups to the patient breathing system.
2. Check for kinks or occlusions in the breathing system.
3. The inspiratory check valve in the absorber may be stuck. Check the inspiratory check valve.
4. Is the patient breathing spontaneously? During mechanical ventilation, spontaneous breathing may trip this alarm.
5. Check the gas-scavenging system for excessive vacuum.

Responding to a LOW MINUTE VOL ! Message

If the ventilator senses that the minute volume is less than the level you set using the low-MV pushwheel, the ventilator will generate an alarm. However, whenever you adjust the tidal volume knob, the rate knob, or the mechanical ventilation switch, or when you exit volume monitor standby, the ventilator will disable the low minute volume alarm for 40 seconds.

If the low minute volume alarm activates:

1. Check the patient.

2. Check the low-$\dot{V}_E$ alarm limit. Is it set correctly?
3. Check for breathing tube disconnections.
4. Check for excessive moisture in the volume sensor cartridge.
5. Check for excessive moisture in the absorber's check valves.
6. Make sure the volume sensor clip is connected securely to the volume sensor cartridge.
7. Make sure the arrows on the volume sensor clip point toward the absorber.
8. Make sure the volume sensor clip is plugged into the anesthesia system's patient interface panel.
9. Replace the volume sensor cartridge. It may be worn out if its rotor is turning too slowly or not at all.
10. Replace the volume sensor clip.

Responding to a LOW BATTERY ! or POWER FAIL ! Message

Two sources can power the control module; the Ohmeda Modulus II Plus Anesthesia System's DC power supply and the system's backup battery. If the anesthesia machine's DC power supply fails, either because of an electronic failure or because the anesthesia system's AC power is lost, then its backup battery takes over. The battery supplies 12 volts, which a device in the anesthesia system converts to five volts for the ventilator to use.

If the voltage from the anesthesia system drops to 4.7 V d-c or less, the ventilator will generate a "LOW BATTERY!" alarm. Pressing the alarm silence button will permanently silence the alarm tone; however the LED will remain lighted and the alarm message will still appear.

If the voltage then drops to 4.6 V d-c or less, the system will generate a "POWER FAIL!" alarm, which will alternate with the low battery alarm. And, within a minute, the ventilator will generate the "VENT FAIL 5!" alarm, which indicates the voltage supplied is insufficient for mechanical ventilation. While this ventilator failure 5 message is displayed, the ventilator's oxygen, airway-pressure, and volume monitors will continue to operate. But mechanical ventilation is disabled whenever this ventilator failure message is disabled.

If the low-battery or power-failure alarm activates:

1. Begin manual ventilation.
2. Switch to an alternative ventilator.
3. After the case, leave the anesthesia system plugged in with the system master switch set to OFF for at least 16 hours to recharge the battery; then test the battery.

Responding to a LIMIT SET ERROR ! Message

If you attempt to set a combination of the inspiratory flow, tidal volume, rate, and inspiratory pause controls that results in a level the ventilator is not designed to deliver, the ventilator will continue to use the most recent acceptable settings, and will generate a ventilator setting error alarm until the control combination is corrected. For example, a tidal volume of 500 mL, combined with a rate of 20 B/min., and an inspiratory flow of 10 liters per minute will trigger a ventilator setting error. To remove the error, either decrease the tidal volume setting, or decrease the rate setting, or increase the flow setting.

If the ventilator setting error alarm activates:

Readjust the ventilator's controls within the ventilator's operating limits.

Responding to a CHECK 02 PROBE! /CHECK GAS SUPPLY Message

If the ventilator doesn't detect any oxygen, it assumes the oxygen probe has failed, and it generates an alarm. An alarm will also be generated if the probe isn't connected correctly, if the probe is broken, or if no oxygen is in the area of the probe.\

If the Check O_2 Probe/Check Gas Supply Message is displayed:

1. Check the oxygen supply.
2. Make sure the oxygen sensor is plugged into the anesthesia system's patient interface panel.
3. Check the oxygen-sensor cartridge's surface for excessive moisture.
4. Has the oxygen sensor been left unplugged from the patient interface panel? If it has, or if the control module has been left disconnected from the panel, an oxide coating may have built up on the sensor's surface. Connecting the sensor through the patient interface panel to the control module will eventually remove this coating. However, up to 12 hours may be required to free the sensor's surface of oxide build-up.
5. Replace the oxygen-sensor cartridge. It may be worn out.

Responding to a REVERSE FLOW ! Message

If the ventilator senses an unacceptable level of reverse flow, it generates an alarm. The level of reverse flow that will trigger a reverse flow alarm depends on the tidal volume you set. If you set the tidal volume knob for less than 300 mL, then 20 mL or more will trigger an alarm. However, if you set the tidal volume knob for 300 mL or more, the ventilator will allow up to 100 mL before triggering an alarm.

The reverse flow alarm is intended to warn you of inadvertent reverse flow conditions, such as those caused by a defective or sticking exhalation check valve. These kinds of conditions will be detected only when the volume sensor is correctly placed at the distal position of the expiratory limb of the breathing system. If you place the volume sensor at the proximal end of the "Y" connector, volume monitoring will still function. However, when the volume sensor is located at the proximal position, a reverse flow condition will occur each time the patient inhales, and the reverse flow alarm will activate for each breath. To disable the reverse flow alarm, select "REVERSE ALARM: OFF" from the Setup Page.

If the Reverse Flow Alarm activates:

1. Make sure the volume sensor assembly is in the expiratory limb of the patient breathing system. If the sensor is in the expiratory limb, check the exhalation valve; its disk may be sticking.
2. Make sure the arrows on the volume sensor clip point toward the absorber.

Responding to a LOW SUPPLY PRES ! Message

If the ventilator supply gas pressure is less than 152 kPa, the ventilator generates a low supply pressure alarm.

If the low supply pressure alarm activates:

1. Check the oxygen supply pressure.
2. Switch to oxygen cylinder use, if necessary.

Responding to a VENT.FAIL X ! or DRIVE CKT. OPEN ! Message

The number in the ventilator failure message--such as "VENT.FAIL 8!"-- will correspond to the specific type of failure that has occurred, in this case a gas inlet valve failure. If a ventilator failure alarm does occur pressing the alarm silence button will permanently silence the alarm tone, although the yellow LED and alarm message will remain on, and the ventilator will not function. During some ventilator failure alarms the ventilator's built-in monitors will continue to function. Mechanical ventilation, however, will be disabled whenever any ventilator failure message except when messages for ventilator failures 6, 8, and drive gas circuit open are displayed.

Ventilator failure messages can indicate anything from a failed ventilator component, transient noise disruption, to excessive pressure in the ventilator's gas supply. All ventilator failure messages except VENT FAIL 6 and DRIVE CKT OPEN will result in the ventilator being stopped. Do not attempt to use the ventilator while a ventilator failure message is displayed. Cycle the system master switch to attempt a ventilator failure message reset. If the ventilator failure message clears, use of the ventilator may be continued with normal observation of ventilator alarms and operation. If the ventilator failure message does not clear, an alternate source of patient ventilation must be used and the ventilator removed form use. Do not use the ventilator if you suspect a malfunction has occurred.

WARNING: The use of electrosurgical units or other device that radiate high-intensity electrical fields can affect the operation of the ventilator and monitors attached to the patient. Maintain as much distance as possible between the electrosurgical leads and the cables to the flow and oxygen sensors. Do not drape the electrosurgical leads across the absorber or the anesthesia machine. Do not let the electrosurgical leads rest on any surface of the anesthesia system. Constant surveillance of all monitoring and life support equipment is mandatory whenever electrosurgical devices are in operation, on, or in the vicinity of the patient.

WARNING: Ventilator failure messages indicate that a problem exists in the ventilator. Do not attempt to use the ventilator while a ventilator failure message is displayed.

If the ventilator failure 4 (supply gas pressure more than 207 kPa) alarm activates:

Have the ventilator supply gas regulator checked.

If the ventilator failure 5 (anesthesia system power failure and battery less than 4.7 Vd-c) alarm activates:

1. Check anesthesia system's power cord.
2. Check the anesthesia system's circuit breaker.
3. Check the power connections between the control module and the anesthesia system.
4. After the case, leave the anesthesia system plugged in with the system master switch set to OFF for at least 16 hours to recharge the battery; then test the battery.

Responding to an APNEA ALARM OFF ! Message

Because very low flow levels that are not sufficient to trigger the volume-sensing circuits may occur in spontaneously breathing patients, the ventilator disables the apnea alarm when the tidal volume knob is set to less than 300 mL and mechanical ventilation is switched OFF. Whenever tidal volume is set to less than 300 mL and the mechanical ventilation switch is OFF, the ventilator, once it has detected a breath, will display "APNEA ALARM OFF!" To enable the apnea alarm while the patient is breathing spontaneously, increase the tidal volume knob to 300 mL or more. Although you should always carefully set the low minute volume pushwheel to enable the low minute volume alarm at an appropriate level, the low minute volume alarm is especially important when the tidal volume knob is set to less than 300 mL, disabling the apnea alarm.

If the "APNEA ALARM OFF!" message is displayed:

This is normal if the tidal volume knob is set below 300 mL and the mechanical ventilation switch is set to OFF.

Responding to a MAX.PRESS=xxx CM Message

Anytime you adjust the inspiratory pressure limit knob, the ventilator will briefly display the pressure limit in centimeters of water. However, if the ventilator is in the non-mechanical ventilation mode and the inspiratory pressure limit is set to more than 60 cm H_2O, the ventilator will also light the yellow alarm LED and will continuously display the "MAX.PRESS=xxx CM" message. This pressure limit reminder is displayed in the non-mechanical ventilation mode only; during mechanical ventilation this reminder is disabled.

Responding When -------- Is Displayed For The Tidal Volume Reading

If, during mechanical ventilation, the system does not sense any volume for two consecutive breaths, the system assumes the volume sensor is disconnected or damaged. However, the system does not send a volume sensor failure message. Instead it displays, on the top line, dashes in place of the tidal volume reading.

If the ventilator indicates a volume sensor failure:

1. Check the connections between the volume sensor cartridge and the sensor clip.

2. Make sure the sensor clip is plugged into the anesthesia system's patient interface panel.

3. Check for obstructions in the volume sensor cartridge that may be preventing the cartridge vanes from spinning.

Responding When The Alarm Silence Button Will Not Silence The Alarm

Certain electronic failures may be so significant as to cause the system to lose the ability to generate ventilator failure messages even though the ventilator has failed. If such a serious failure occurs, the alarm silence button will not silence the alarm. Do not attempt to use the ventilator if this type of failure occurs.

WARNING: Do not attempt to use the ventilator if the alarm silence button will not silence alarms.

If the alarm won't silence:

1. Ventilate the patient manually.

2. Switch to a functioning system.

Responding when VOL MON STANDBY ! is displayed in place of $\dot{V}_E$ V_T, or rate readings

When the mechanical ventilation switch is OFF--when the ventilator is in its Monitoring mode--pressing the alarm silence button cancels and resents the apnea and low minute volume alarms; the "VOL MON STANDBY!" message will be displayed and these two alarms will not sound again even if these alarm conditions continue. However, if the ventilator senses another breath, the alarm timers and sensor circuits will again be activated and any alarm condition that occurs will trigger an appropriate alarm.

Responding when ???????? is displayed in place of V_E, V_T, or rate readings

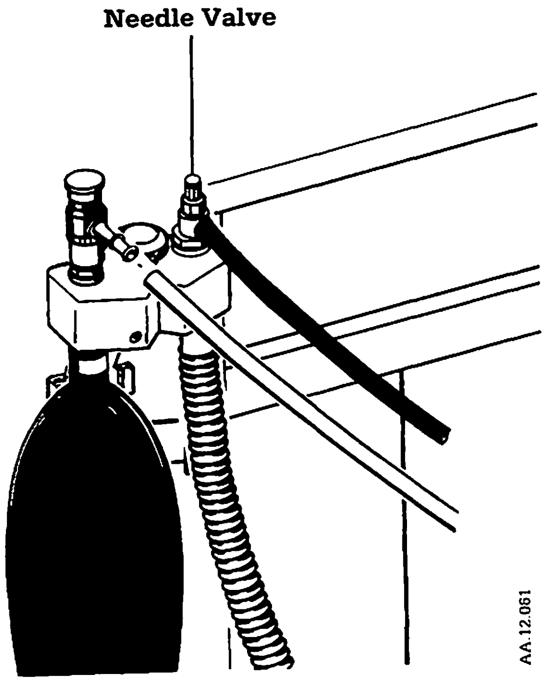
Certain combinations of ventilator front panel control settings can result in ventilation conditions the ventilator can deliver but the cannot measure. If you attempt to set a combination of the controls that results in a level the ventilator is not designed to deliver, the ventilator will generate a ventilator setting error alarm. If you set a control combination the ventilator can deliver, but the volume monitor cannot measure, or if--in the non-mechanical ventilation mode--breathing occurs that the monitor cannot measure, the ventilator will display question marks in place of the V_T,$\dot{V}_E$, and rate readings.

5.11 Adjusting The Waste gas Scavenging Interface Needle Valve

When you are using the Ohmeda waste gas scavenging interface valve assembly with a high-vacuum disposal system, you must adjust the assembly's needle valve to prevent the reservoir bag from filling to capacity.

1. Set the gas flow as previously described in this section.
2. Adjust the assembly's needle valve so the reservoir bag oscillates between half-full and completely collapsed during each normal breathing cycle.
3. If the vacuum level for your scavenging system changes, readjust the assembly's needle valve.

Figure 5-8
Adjusting the scavenging interface valve in a high vacuum system



5.12 Shutting Down The System

After using the Ohmeda Modulus II Plus Anesthesia System:

1. Move the system master switch to OFF and turn OFF the mechanical ventilation switch on the ventilator.
2. Make sure all vaporizers are switched OFF.
3. Remove the patient circuit from the absorber.
4. Close all of the flow controls.
5. Disconnect all of the pipeline supplies.
6. Open the cylinder valves.
7. Fully open the flow control valve for air.
8. Fully open the flow control valve for nitrous oxide.
9. Fully open the flow control valve for oxygen.
10. Close the air cylinder valve. Before moving to the next step, wait until the float in the flowmeter for the third gas drops to the bottom of its tube.
11. Close the nitrous oxide cylinder valve. Before moving to the next step, wait until the float in the nitrous oxide flowmeter drops to the bottom of its tube.
12. Close the oxygen cylinder valve. Before moving to the next step, wait until the float in the oxygen flowmeter drops to the bottom of its tube.
13. Move the system master switch to OFF.
14. Close all of the flow control valves.
15. Leave the system's electrical power cord plugged into the hospital grade wall outlet and the master switch turned ON to provide battery charging while the machine is not in use.

6/Maintaining the System

6.1 Maintenance Schedule

The following schedule is a recommended minimum standard based upon normal usage and environmental conditions. Higher frequencies of use or unusual environments may dictate more frequent maintenance.

When lubricating any part of the anesthesia machine, always use an approved oxygen service lubricant. Ohmeda recommends Vac Kote or KRYTOX.

WARNING: Never oil or grease any oxygen equipment unless the lubricant used is made and approved for this type of service. In general, oils and greases oxidize readily, and—in the presence of oxygen—will burn violently. Vac Kote or KRYTOX are the recommended oxygen service lubricants.

Cleaning:

Painted Areas	Daily
Stainless Steel and Chrome	Daily
Anodized Aluminum	Daily
Clear Plastic Areas	Daily
Rubber and Plastic Components of the Frame	Daily

Lubrication:

Yoke tee Handle	As required

Replacement:

Oxygen sensor	As required Minimum Annually
Volume sensing cartridge	Every 30 days
Vaporizer manifold O-rings	Yearly
Strainer Nipple	Yearly
Battery	Every two years

6.2 Cleaning And Sterilizing

This chart is intended to serve as a quick reference once you are familiar with the cleaning and sterilization of the system. Refer to the text following the chart for cleaning-and-sterilization details. Use a cleaning and sterilization schedule that conforms to your institution's sterilization and risk-management policies.

ITEM	TO CLEAN	TO STERILIZE
Ventilator Control Module	mild detergent	n/a
Bellows Assembly	mild detergent	ethylene oxide
Volume Sensor Clip Assembly	damp cloth	disinfectant
Volume Sensor Cartridge	damp cloth	ethylene oxide
Oxygen Sensor Probe Housing	damp cloth	ethylene oxide

ITEM	TO CLEAN	TO STERILIZE
Oxygen Sensor Cartridge	a damp cloth white vinegar, or water	ethylene oxide
Painted Areas	damp cloth soap	n/a
Stainless Steel, Chrome	damp cloth Bon Ami™	n/a
Anodized Aluminum	damp cloth Bon Ami™	n/a
Clear Plastic Areas	damp cloth	n/a
Rubber, Plastic	damp cloth, mild alkali detergent	cold germicidal detergent ethylene oxide
Scavenging Interface Relief Valve Manifold	soap and water	ethylene oxide

™ Bon Ami Tradename of Chemagro Corp

Cleaning The Control Module

Clean the exterior surfaces of the control module with a soft, lint-free cloth lightly moistened in a solution of mild liquid detergent.

CAUTION: Use cleaning solution sparingly. Do not saturate system components. Excessive solution can damage internal devices.

CAUTION: Do not cover the system with any type of fabric or plastic covering. These types of coverings can generate static charges that may damage the equipment.

Cleaning And Sterilizing The Bellows Assembly

Reduce the risk of cross-infection

Because of the temperature difference between exhaled patient gases and the room environment, water droplets may form in the breathing system. This droplet formation is normal and particularly noticeable in the bellows and bellows base. Periodically clean and sterilize the bellows assembly to reduce the risk of cross-infection and to help keep the ventilator working properly. The bellows is an expendable item; replace the bellows periodically and whenever it shows any sign of damage.

WARNING: Sterilize the bellows assembly periodically to minimize the risk of cross-infecting patients. Use a sterilization schedule that complies with your institution's infection-control and risk-management policies. Use Ohmeda-approved sterilization methods.

CAUTION: The bases for the adult and pediatric bellows assemblies use different seals and are not interchangeable. Do not mix parts for these two assemblies. Interchanging parts for these assemblies may cause the bellows assembly to malfunction.

CAUTION: Perform the Preoperative Checkout Procedure after cleaning and sterilizing the bellows assembly.

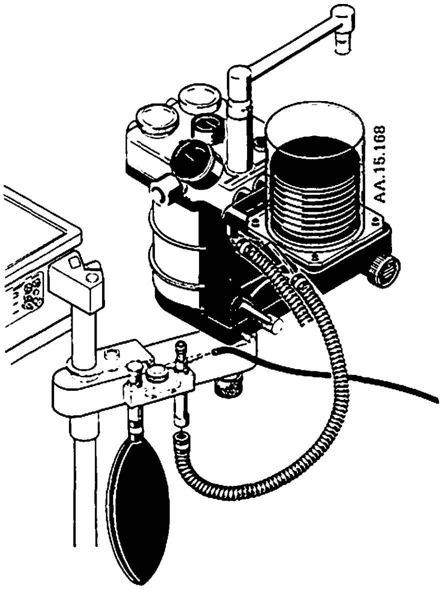
Disassembling The Bellows Assembly

See section 8 for Ohmeda's Autoclavable Bellows Assembly (ABA).

1. Turn OFF the master switch and unplug the system's a-c power cord.

2. Remove all hose connections from the bellows assembly.

Figure 6-1
Disconnecting hoses from the bellows assembly



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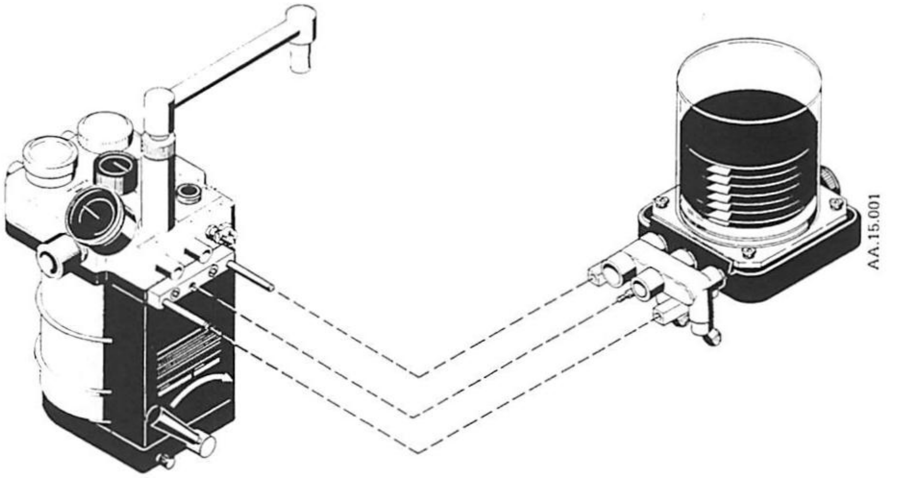
3. Detach the bellows assembly from the Ohmeda GMS Absorber:
   a. Turn the locking knob counterclockwise until the locking rod releases.
   b. Hold the entire assembly firmly and slide the support guides off the support pins.

4. To remove the adult bellows housing, remove the four thumbscrews that attach it to the base, then lift the housing off the bellows assembly's base.

5. See figure 6-6 for a guide if you need to disassemble the bellows assembly further for cleaning or sterilization.

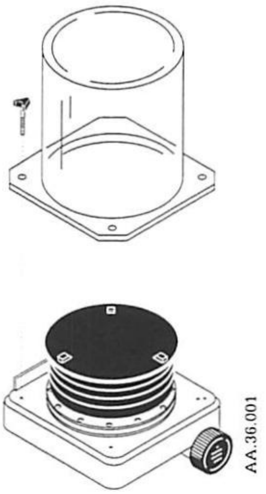
6. Remove the interface manifold from the bellows base.

Figure 6-2
Detaching the bellows assembly from the absorber



7. To remove the adult bellows, lift the bellows off the base ring.

Figure 6-3
Removing the adult bellows housing



8. To remove the pediatric bellows adapter and adapter ring:

Removing the pediatric bellows adapter and ring from a pediatric bellows assembly

   a. Grasp the adapter ring by its bottom edge and gently pull it up and off of the adapter.

   b. Lift the adapter off of the bellows base.

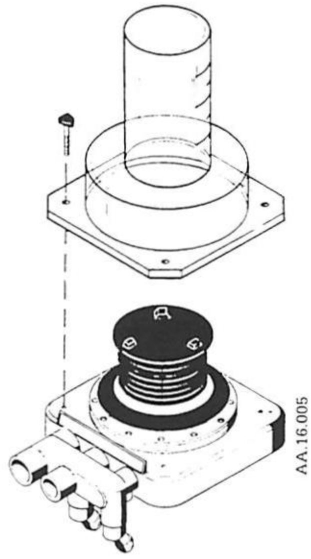
Removing the pressure relief valve (all configurations)

9. If you must remove the pressure relief valve from the bellows base, do not attempt to disassemble the valve itself. To remove the pressure relief valve:

   a. Remove the three thumbscrews that hold the valve in place.

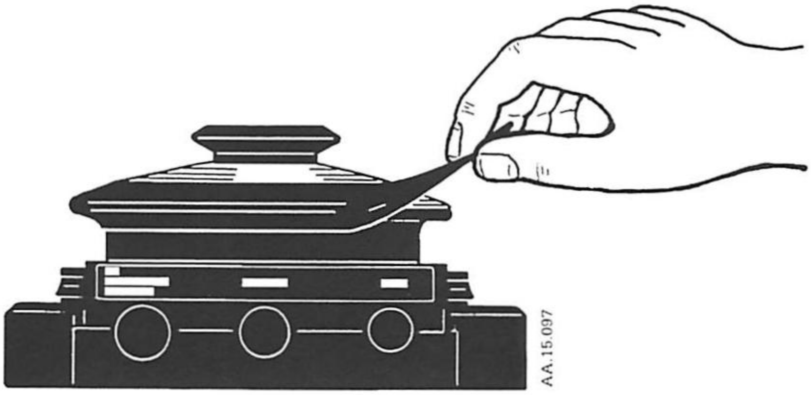
   b. Lift valve off of the bellows base.

Figure 6-4 Removing the pediatric bellows housing



Before reassembling the bellows assembly, check all of the rubber parts, including the bellows, for swelling, tackiness, holes, cracking, or any other signs of damage. Rubber devices, which deteriorate, are expendable and must be replaced periodically.

Figure 6-5 Removing the pediatric bellows assembly's adapter ring



Cleaning The Bellows Assembly

Wash the bellows housing

1. Wash the bellows housing in a mild soap-and-water solution. Use cold water to thoroughly rinse the housing of all soap. Dry the housing with a soft, lint-free cloth.

Wash the bellows

2. Wash the bellows (and—for the pediatric bellows only—the base and ring) in a mild soap-and-water solution. Use cold water to thoroughly rinse the bellows of all soap. Remove excess water from the bellows, then dry the bellows by hanging it from its top disk for at least twelve hours.

   Allow the bellows to dry completely; moisture remaining in the folds of the bellows may make the bellows tacky, causing the bellows to operate improperly.

Wash the pressure-sensing tube

3. Wash the pressure-sensing tube with a mild soap-and-water solution. Use cold water to thoroughly rinse the tube of all soap. Remove all soap and water from inside the tube. Dry the tube thoroughly.

The pressure relief valve

4. Do not immerse the pressure relief valve in liquid. Immersion can trap liquids in the valve, impairing the valve's performance. Clean the valve's exterior surfaces with a soft cloth dampened with a solution of warm water and mild, liquid detergent. Do not let liquid enter the drive-gas port. Dampen a clean, soft cloth in cold water and use the cloth to wipe the valve clean. Let the valve dry completely before use or sterilization.

The bellows base

5. Do not immerse the bellows base in liquid. Immersion can trap liquids in the driving gas circuit of the base which impairs the bellows assembly's performance. Clean the base's exterior surfaces with a soft cloth dampened by a solution of warm water and mild, liquid detergent. Do not let liquid enter the drive-gas ports. A bottle brush may be used to clean the ports labeled "To Anesthesia Machine" and "Exhaust." The 17-mm "Inlet" port is normally exposed to only oxygen and shouldn't need cleaning. Use a clean cloth or bottle brush dampened in cold water to remove all traces of soap from the bellows base. Let the base dry completely before clinical use or sterilization.

WARNING: Liquids or any foreign materials trapped in the driving-gas circuit of the pressure relief valve or the bellows base can impair the valve's operation. Do not use the pressure relief valve or bellows base if you suspect that materials are trapped. Have the assembly repaired by trained service personnel.

Wash the interface manifold

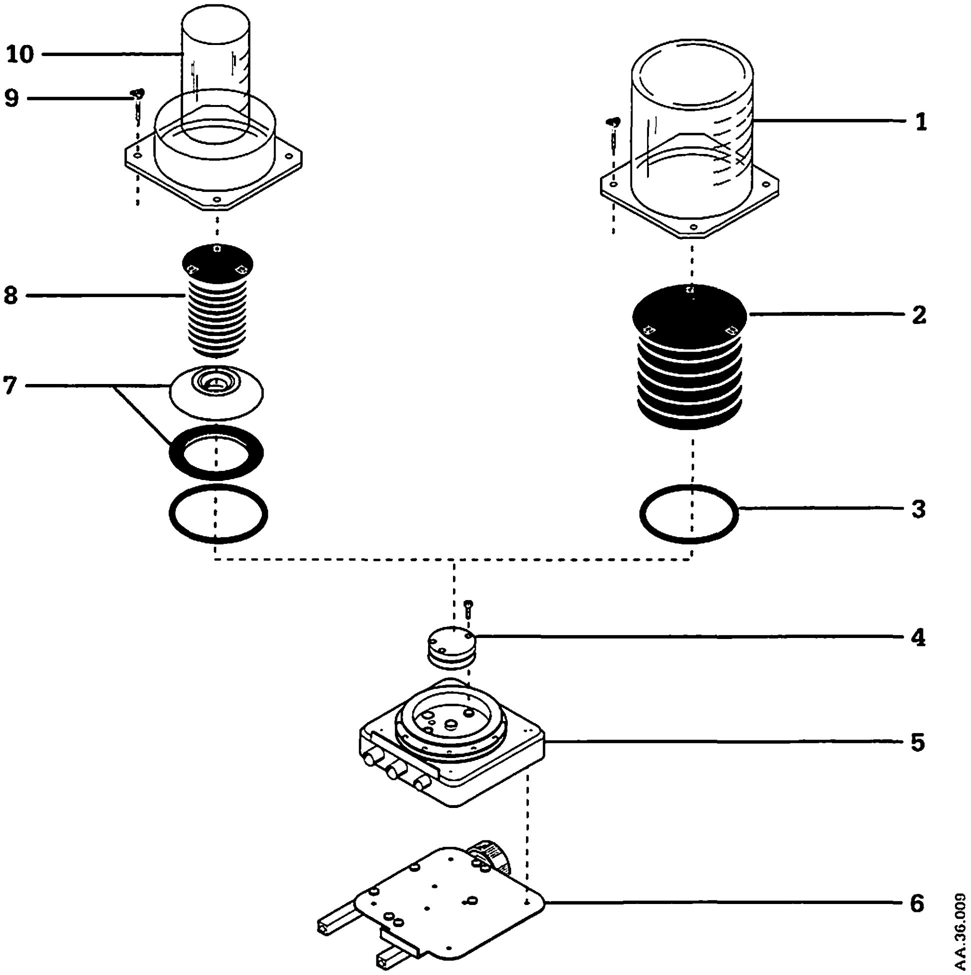
6. Wash the interface manifold with a mild soap-and-water solution. Use cold water to thoroughly rinse the manifold of all soap. Dry the interface manifold thoroughly.

Sterilizing The Bellows Assembly

To sterilize the bellows assembly

The adult and pediatric clear-plastic bellows housings require sterilization only if the bellows has torn or leaked. Normally the bellows exteriors are exposed only to driving gas. If the bellows assembly must be sterilized, wash and completely dry the bellows assembly's components as described in the previous steps. To further sterilize the bellows assembly's components, you may also use an ethylene oxide mixture at 52 to 57°C (125 to 135°F), or room temperature sterilization with 100% ethylene oxide. Follow the sterilizer manufacturer's recommendations.

Figure 6-6 Adult and pediatric bellows assemblies, exploded views



1. Adult bellows housing
2. Adult bellows
3. Seal
4. Pressure relief valve, do not disassemble
5. Bellows base
6. Base plate
7. Pediatric bellows base and ring
8. Pediatric bellows
9. Thumbscrews
10. Pediatric bellows housing

CAUTION: After ethylene oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

Reassembling The Bellows Assembly

Before reassembling the bellows assembly, check all of the rubber parts—including the bellows—for swelling, tackiness, holes, cracking, or any other signs of damage. Rubber devices, which deteriorate, are expendable and must be replaced periodically.

To reassemble the bellows assembly, perform the steps in "Disassembling the bellows assembly" in reverse order. Before using the ventilator, perform the preoperative checkout procedures described in section "4/Preoperative Checkout Procedures."

6.3 Checking the volume sensor

This volume-sensing checkout procedure, which you should perform before each case, tests both the sensor cartridge and the sensor assembly. If the checkout fails, replace the volume cartridge, then repeat the procedure. If the checkout still fails after you replace the cartridge, replace the sensor assembly and repeat the test again.

To check volume sensing

1. Add a bag to the patient circuit at the "Y" connector.
2. Set the tidal volume to 500 mL.
- The ventilator displays: 500 mL I :E 1:X.X

3. Set the rate to 10 breaths per minute.
- The ventilator displays: 10/min I :E 1:X.X

4. Using the inspiratory flow knob, set the I:E ratio to 5.0. This corresponds to a flow of 30 liters per minute.
- The ventilator displays: I:E=1:5.0

5. Set the inspiratory pressure limit to 40 cm H_2O.
- The ventilator displays: PMAX=40 SUST=20

6. Make sure that the ventilator's inspiratory pause function is OFF.
7. Set the low $\dot{V}_E$ alarm limit to 0.0 liters per minute.

8. Set the anesthesia system's oxygen flow to 2 liters per minute.

9. Ensure that the volume sensor cartridge is on the exhalation side of the breathing system. Make sure that the arrows on the sensor clip point in the direction of exhaled gas flow.

10. Move the absorber's bag-to-ventilator switch to the ventilator position, if applicable.

11. Use the anesthesia machine's O_2 flush button to fill the bellows.

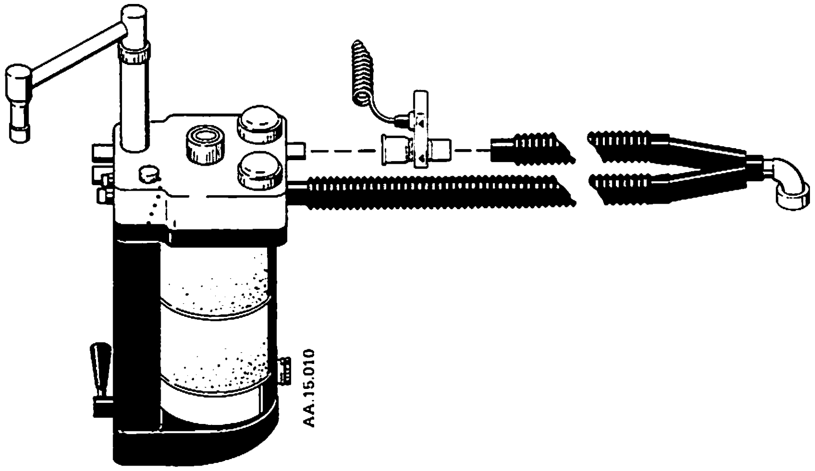


Figure 6-7
Adding a breathing bag at the patient circuit's "Y" connector

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12. Switch ON mechanical ventilation and wait 40 seconds. The displayed $\dot{V}_E$ should be between 3.3 liters and 4.3 liters per minute assuming that your system:

- includes an adult bellows
- includes 60-inch patient tubes
- does not include a humidifier
- has a peak inspiratory pressure of 15 cm H_2O

(If your system's components and peak inspiratory pressure are different than this, see "Tidal volume compensation" in section 3 to calculate the compliance factor of your system. Then use this factor to calculate the expected minute volume.)

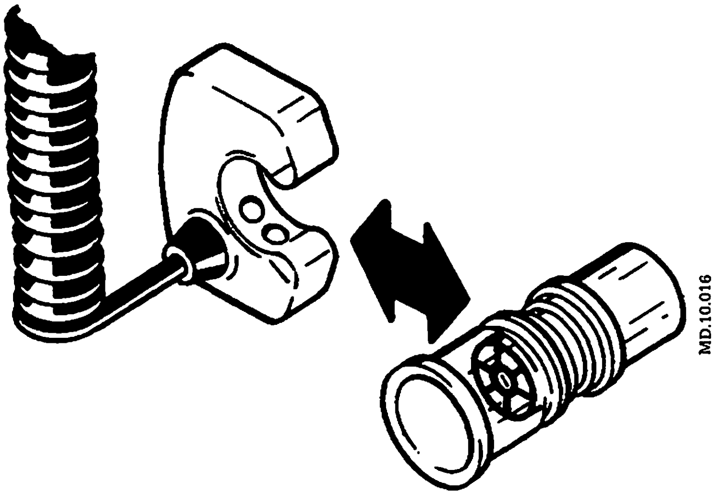
Cleaning and sterilizing the volume sensor clip assembly

Because no part of the sensor assembly—which includes the clip, cable and plug—is exposed to the breathing system, usually no sterilization is required. If the clip, cable and plug do need cleaning:

1. Unplug the sensor from the sensor interface panel.
2. Remove the sensor clip from the volume cartridge.
3. Wipe the clip, cable and plug with a cloth moistened in disinfectant (liquid sterilizing).

CAUTION: Never immerse any part of the volume sensor assembly in cleaning solution. Immersion will destroy the clip's electrical contacts.

Figure 6-8 Disconnecting the volume sensor cartridge from its clip



Cleaning and sterilizing the volume sensor cartridge

Replace the sensor cartridge at least every thirty days, or when the volume sensor checkout (see "Checking the volume sensor") indicates the sensor has become inaccurate. If cleaning is required between replacements:

Note: Be very careful while you are handling the volume cartridge. The cartridge is a precision device containing jeweled bearings. Do not drop the cartridge. Do not allow any contaminant, such as hair or dust, to enter the cartridge.

1. Remove the cartridge from the breathing system.
2. Unsnap the sensor clip from the cartridge.
3. Use an accepted gas or liquid sterilization technique to sterilize the sensor cartridge.

CAUTION: Never insert cleaning brushes or other foreign objects through the cartridge vanes. Contacting the sensor's moving vane may damage its precision movement.

CAUTION: Following ethylene oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

CAUTION: Always perform the preoperative checkout procedures for volume sensing functions after cleaning or replacing the volume sensor cartridge, see section 4.

6.4 O_2 sensor maintenance

Maintenance schedule

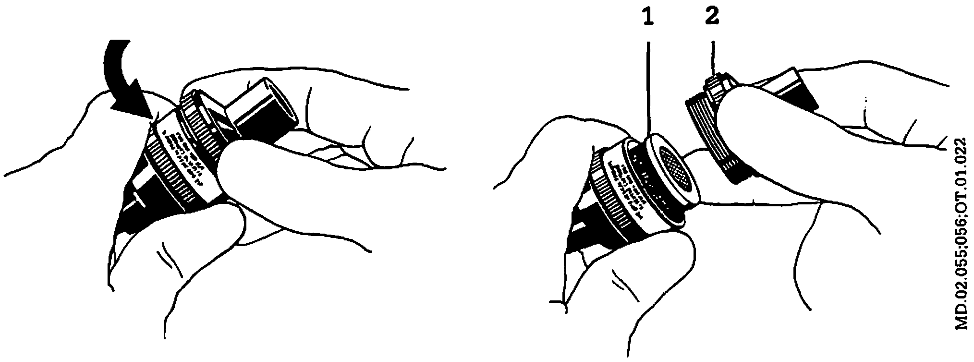
Before each use	• Preoperative checkout procedure (includes 21% O_2 calibration
Monthly	• 100% O_2 calibration
Annually	• Replace the O_2 sensor cartridge. Cartridge life expectancy is one year at 50% O_2 and 24°C (77°F). Different operating conditions (higher concentrations, high temperature, and elevated CO_2 concentrations) can shorten cartridge life expectancy. Freezing can destroy the sensor cartridge

6.5 Installing a cartridge or disassembling the O_2 sensor for cleaning

WARNING: Use protective gloves and eye-wear when you open the O_2 sensor in case the cartridge is leaking. The sensor cartridge contains potassium hydroxide (caustic).

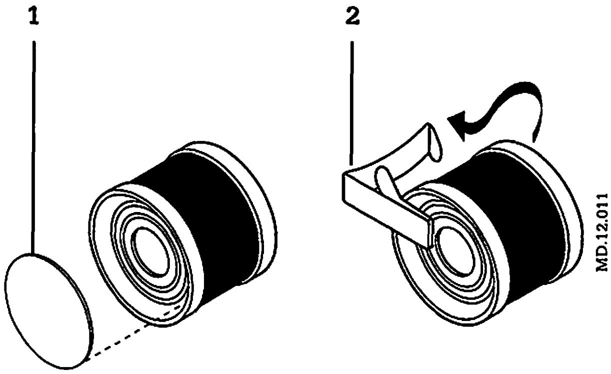
CAUTION: Handle the cartridge with care to avoid damaging it. Always perform the calibration and preoperative checkout procedures for oxygen-sensing functions after replacing a new sensor cartridge or a recently cleaned and sterilized oxygen sensor.

Figure 6-9
Open the sensor housing and remove the old cartridge



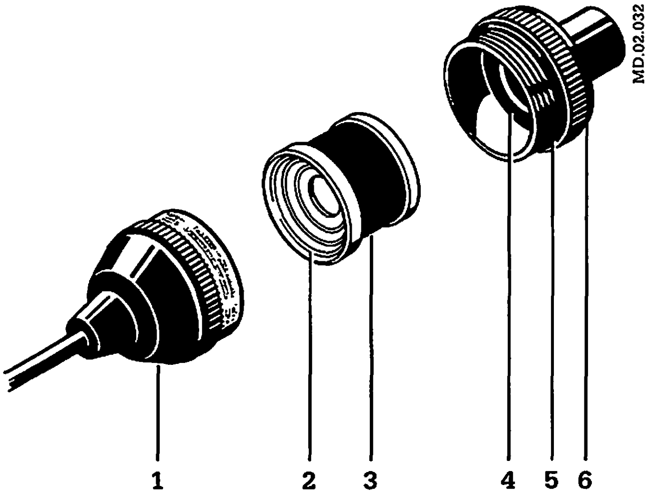
1. Sensor screen
2. Probe section of housing

Figure 6-10
Remove the metal disk or clip and retain for shorting the cartridge during future maintenance



1. Shorting disk
2. Shorting clip

Figure 6-11
Install a new cartridge with circular contacts toward the cable end of the housing, screen facing out



1. Cable section
2. Contact rings
3. Sensor cartridge
4. Inner O-ring
5. Outer O-ring
6. Probe section

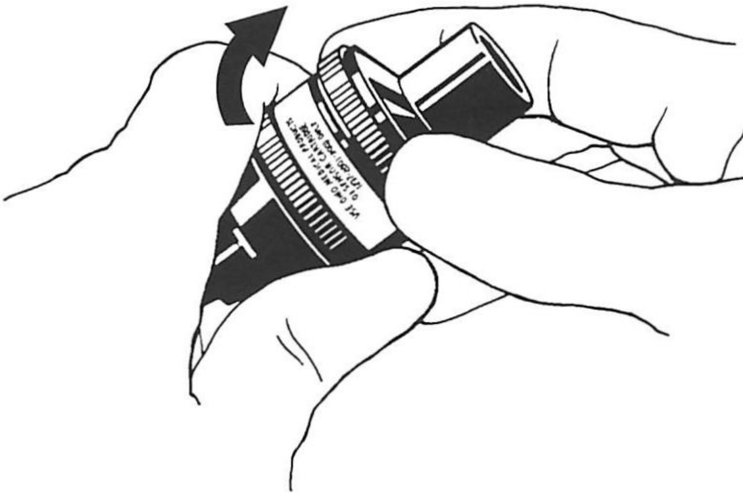


Figure 6-12
Finger tighten the housing to a gas tight seal

MD.02.055;OT.01.019

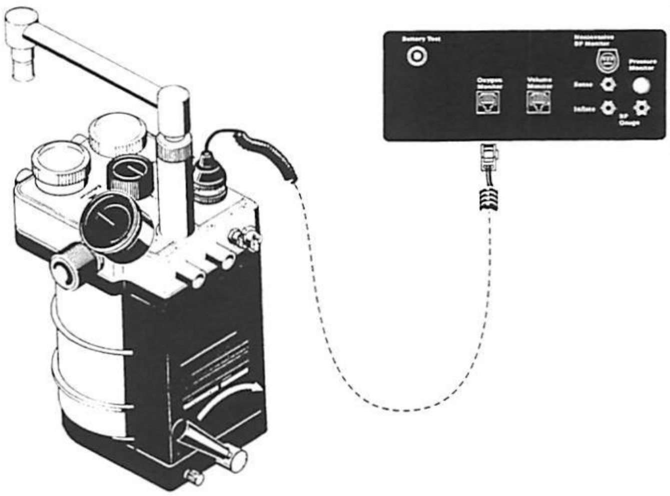

Battery Test
Noninvasive BP Monitor
Pressure Monitor
Oxygen Monitor
Volume Monitor
Sense
Inflate
BP Gauge

Figure 6-13
Immediately connect the O_2 sensor

AA.15.166;AA.23.025

Cleaning and sterilization

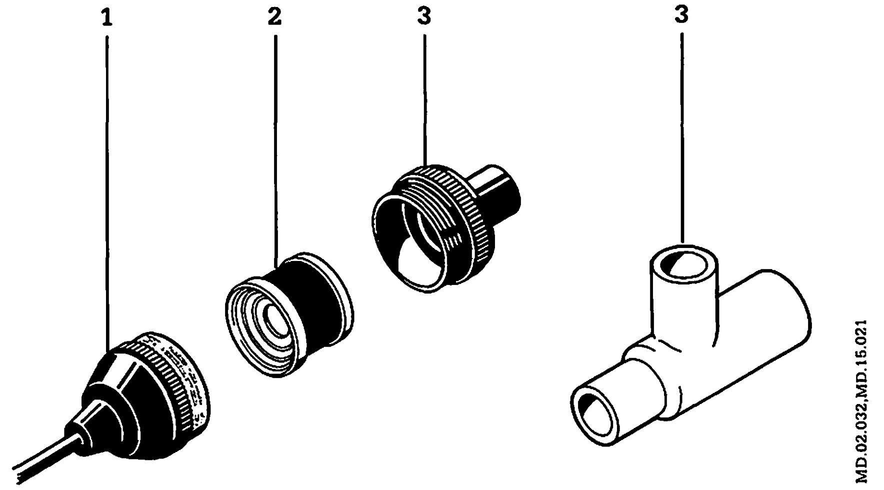
⚠

WARNING: Use protective gloves and eye-wear when you open the O_2 sensor in case the cartridge is leaking. The sensor cartridge contains potassium hydroxide (caustic).

WARNING: Do not inhale any fumes generated by the oxygen-sensor cleaning procedure. Such fumes can cause respiratory system or skin damage. This material is caustic.

CAUTION: Following ethylene oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

Figure 6-14
Cleaning and sterilization methods



1. Cable Section -- Wipe with a damp cloth (liquid disinfectant, mild detergent, isopropyl alcohol); do not immerse, gas sterilize, or autoclave; remove oxide from leaked electrolyte under a fume hood with vinegar using eye and skin protection.

2. Sensor Cartridge -- Gas sterilize with ethylene oxide (ambient temperature, no vacuum or pressure) or wipe with a damp cloth (water, white vinegar, liquid disinfectant): do not immerse or autoclave; do not use alcohol.

3. Probe Section and Optional Sensor Tee -- Gas sterilize with ethylene oxide or clean with liquid disinfectant, mild detergent solution or isopropyl alcohol.

6.6 100% O_2 calibration

At least once a month and following sensor cartridge replacement, calibrate the oxygen sensor using 100% O_2.

1. Adjust the high O_2 alarm to 00% (alarm disabled).

2. Expose the O_2 sensor to pure oxygen and allow the display to stabilize for approximately two minutes as oxygen fills the patient circuit.

3. Adjust the calibration control until the display reads 99%.

4. Expose the O_2 sensor to room air and allow the display to stabilize for approximately two minutes as room air fills the sensor housing. If the final reading is outside the allowed range 21 ± 3% (18 to 24%), the sensor cartridge is no longer linear and must be replaced. Refer to "Installing a cartridge or disassembling the O_2 sensor for cleaning " in this section.

5. If the system will not be used immediately, switch the monitor or system OFF.

Cleaning The Anesthesia Machine

Painted Areas

Clean painted or enameled surfaces using a damp cloth and mild soap. Do not use abrasive cleansers; abrasive cleaners may scratch the paint.

Stainless Steel And Chrome

Clean stainless steel and chrome surfaces using a damp cloth. For stubborn stains, apply Bon Ami™ on a damp cloth, and scrub.

Anodized Aluminum

Clean anodized aluminum surfaces using Bon Ami on a damp cloth. Do not use abrasive cleansers; they can mar the finish.

Clear Plastic Areas

Clean clear plastic surfaces using a soft, clean cloth, dampened slightly in warm, clean water. To prevent spotting, immediately dry the surface with a soft, clean cloth. Cleaning agents (abrasive and non-abrasive), glass cleaners, and anesthetic agents will mar or damage the plastic.

Rubber And Plastic Components

Clean rubber and plastic components of the frame using a soft cloth and warm water. If necessary, a mild, alkali detergent may be used to remove stains.

The Care and Cleaning of Rubber Articles

Rubber goods, whether natural or synthetic, deteriorate over a period of time, and therefore must be considered expendable and subject to periodic replacement. The presence of oxygen, ozone, ether, mineral or vegetable oils, phenols, cresols, terpenes, hydrocarbon solvents, chlorinated-hydrocarbon solvents, chlorinated hydrocarbons, esters, or oxidizing acids will hasten the deterioration.

Rubber articles should be checked often for swelling, tackiness, or cracking. When any of these are evident, the affected parts should be replaced.

Conductive rubber goods lose their electrical conductivity with age. National Fire Protection Association (NFPA) regulations (pamphlets number 56A) state the requirements for rubber conductivity.

The useful life of rubber articles can be prolonged by following a program of intelligent use and care. Hospital personnel should carefully review the following suggestions:

1. Remove metal connectors immediately after use.
2. When possible, store rubber articles in the dark, away from sources of ozone generation, such as fluorescent lighting fixtures, electric motors, and diathermy machines.

WARNING: Talc, zinc stearate, calcium carbonate, or corn starch that have been used to prevent tackiness of rubber articles could contaminate a patient's respiratory tract.

Sterilizing The Anesthesia Machine

Cold Sterilization

Rubber goods may be washed with a mild, alkali detergent and sterilized in a cold, germicidal solution, intended for use with water. Always follow the sterilizing agent manufacturer's recommendations.

Steam Sterilization

Do not steam sterilize the Ohmeda Modulus II Plus Anesthesia System.

Gas Sterilization

For sterilizing rubber goods, ethylene oxide at 52 to 57°C (125-135°F) can be used. Room temperature sterilization is also effective: expose rubber goods to 100% ethylene oxide for 12 hours.

CAUTION: Following ethylene-oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

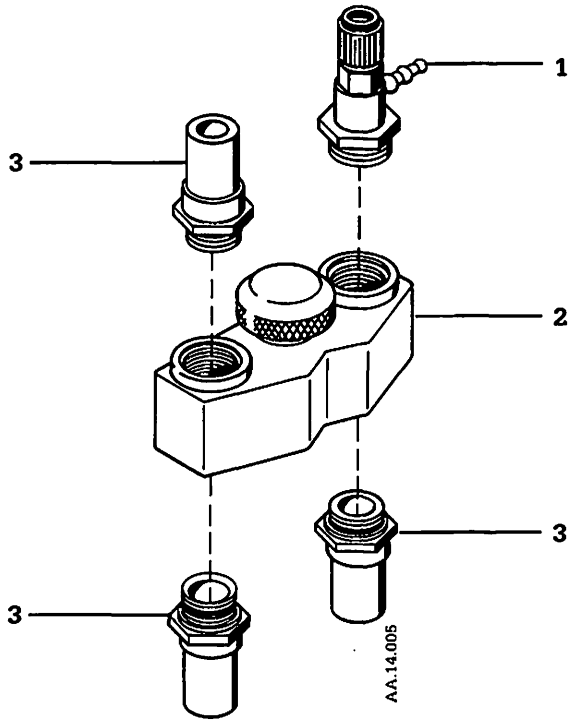
Cleaning The Waste Gas Scavenging Interface Relief Valve

To clean the positive-and-negative relief valve, disassemble the interface valve assembly by removing the connectors from its four ports. Do not disassemble the relief valve. Clean the parts in soap and water; an ultrasonic bath may be used. Do not use any cleansing agent that contains abrasive materials. Rinse the parts with clean water and dry thoroughly. Then reassemble the interface valve assembly. To lubricate the needle valve, use only an approved, oxygen-service lubricant. A small amount on the threaded portion is all that is needed.

WARNING: Never oil or grease any oxygen equipment unless the lubricant used is made and approved for this type of service. In general, oils and greases oxidize readily, and—in the presence of oxygen—will burn violently. Vac Kote™ or KRYTOX™ are the recommended oxygen service lubricants.

WARNING: After performing any maintenance or repair procedure, always verify proper operation of the Ohmeda waste gas scavenging interface valve.

Figure 6-15
Scavenging interface valve, exploded view



1. Needle valve
2. Central manifold
3. 19-mm connector

6.7 Lubricating The Anesthesia Machine

WARNING: Never oil or grease any oxygen equipment unless the lubricant used is made and approved for this type of service. In general, oils and greases oxidize readily, and—in the presence of oxygen—will burn violently. Vac Kote™ or KRYTOX™ are the recommended oxygen service lubricants.

When required, apply lubricant sparingly to the yoke tee handle threads. This will prolong their life and make it easier to seal cylinder gaskets. Vac Kote or KRYTOX can be ordered from Ohmeda.

Do not lubricate the absorber post assembly.

6.8 Maintaining The Gas Supply Module

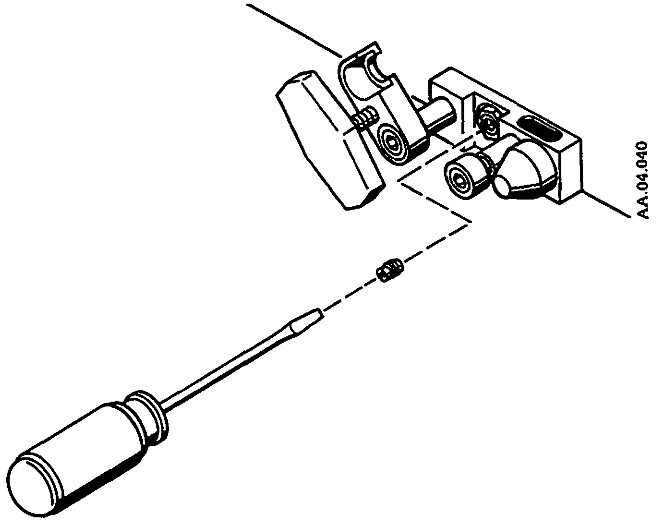
Install yoke plugs and gaskets in unused yokes to help prevent check valve leaks and to keep dust and lint from accumulating in the strainer nipples. The strainer nipples are located in the cylinder yokes and, even with conscientious use of yoke plugs, should be replaced at least once a year.

To replace a strainer nipple:

1. Remove the gas cylinder, if present.
2. Swing the yoke gate to the left.
3. Use a flat-tipped screwdriver to unscrew the old strainer nipple out of the cylinder inlet.
4. Screw the replacement strainer securely into the cylinder inlet.

   The tee handle screw can be unscrewed from the yoke gate and replaced if necessary.

Figure 6-16 Replacing a strainer nipple on a gas supply module



7/Troubleshooting

7.1 Troubleshooting Guide

This guide is divided into three sections: system problems, ventilator problems and ventilator failure messages.

Repair policy

Do not use malfunctioning equipment. Make all necessary repairs, or have the equipment serviced by an authorized Ohmeda representative. After repair, test the equipment to ensure that it is functioning properly, in accordance with the manufacturer's published specifications.

To help ensure full reliability, have all repairs and service done by an authorized Ohmeda representative. If this cannot be done, replacement and maintenance of those parts listed in this manual may be undertaken by a competent, trained individual having experience in the repair of the Ohmeda Modulus II Plus Anesthesia System with 7810 Ventilator and having appropriate test and calibration equipment.

CAUTION: No repair should ever be undertaken or attempted by anyone not having proper qualifications and equipment.

Replace damaged parts with components manufactured or sold by Ohmeda. Then test the unit to ascertain that it complies with the manufacturer's published specifications.

In some cases, special diagnostic equipment may be required to properly service components of the Ohmeda Modulus II Plus Anesthesia System with 7810 Ventilator. The components must then be sent to the nearest Ohmeda Service Center.

Troubleshooting System Problems

Symptom	Possible Cause	Recommended Action
System won't power ON when connected to functional AC outlet.	Master switch is OFF.	Move master switch to ON.
	Battery completely discharged.	Press battery bypass button to restart system, then recharge battery.
No Gas Flow	Master switch is OFF.	Move master switch to ON.
	O_2 supply pressure too low.	Check the pipeline, switch to cylinder.
	Supply hose disconnected.	Connect supply hose.
	Kinks in supply hose.	Remove kinks from supply hose.

Troubleshooting System Problems, continued

Symptom	Possible Cause	Recommended Action
Electrical/Disconnect Failure Alarm Activates	System power cord unplugged.	Plug in power cord.
	Circuit breaker tripped.	Reset circuit breaker (see section following).
	System's DC power supply has failed.	Call service personnel.
O_2 Supply Failure Alarm Activates.	O_2 supply pressure too low.	Check the pipeline, switch to cylinder.
	Cylinder empty.	Replace cylinder.
	Supply hose disconnected.	Connect supply hose.
	Kinks in supply hose.	Remove kinks from supply hose.
Excessive High Pressure Circuit Leak	Yoke gate loose.	Tighten yoke tee handle.
	Cylinder gasket leaking.	Replace cylinder gasket(s).
	Unused cylinder yoke is unplugged.	Install yoke plug in unused cylinder yoke.
Excessive Low Pressure Circuit Leak	Vaporizer filler or drain valve loose.	Tighten vaporizer filler and drain valves.
	Vaporizer mounted improperly.	Ensure proper vaporizer mounting.
Cannot make a connection to the absorber at one of the anti-disconnect fittings.	Release tab engaged.	Depress the release tab button on the female fitting and try again.

Ventilator problems

Symptom	Possible cause	Recommended action
Bellows does not expand during ventilation or tends to collapse.	Leak in the breathing system.	Check breathing system hoses and connections.
	Bellows not installed properly.	Check bellows to base attachment.
Bellows does not expand during ventilation or tends to collapse.	Tear or leak in bellows.	Check the entire surface of the bellows. Pay close attention to the angles in the convolutions
	Insufficient fresh gas flow.	Check that settings on flowmeter are adequate.
Bellows does not descend during inspiration	Drive gas hose disconnected	Reconnect drive gas hose
	Ventilator switch in APL/Bag position	Place switch in Vent position

Ventilator problems, continued

Symptom	Possible cause	Recommended action
Bellows distended or slips off the base.	Incorrect scavenging system pressure.	Check the scavenging system for vacuum or high pressure.
Low pressure alarm sounds continuously.	Leaks in pressure sensing tube.	Replace pressure sensing tube.
	Circuit disconnected.	Reconnect circuit.
	Circuit occluded.	Clear circuit.
Transient apnea alarm is triggered by sigh breath.	Breath rate is set to two (2), sigh function is enabled, and sigh breath occurring.	This is normal. No action is required.
System sounds alarms at incorrect pressures.	Liquid in pressure sensing tube	Drain the sensing tube.
	Tube disconnected.	Reconnect the tube.
	Kink in tube.	Replace the tube.
Volume readings are consistently low.	Low oxygen supply pressure	Check, and repair, the oxygen supply.
	Failed volume sensor cartridge.	Replace the volume sensor cartridge.
	Breathing system leak.	Find and repair leaks.
	Control module's altitude compensation set incorrectly.	Reset the altitude compensation as described in "Setting the altitude compensation" in section "2/Getting Started."
Volume readings are high.	Control module's altitude compensation set incorrectly	Reset the altitude consistently compensation as described in "Setting the altitude compensation" in section "2/Getting Started."
Alarms sound without apparent cause and cannot be silenced.	Certain electronic failures may be so significant as to cause the system to lose the ability to generate ventilator failure messages even though the ventilator has failed. If such a serious failure occurs, the alarm silence button will not silence the alarm.	Do not use the ventilator.
Reverse flow alarm is activated. (While the volume sensor is in the distal position of the expiratory limb of the breathing circuit.)	Expiratory check valve on absorber is functioning incorrectly.	Replace disk.
Reverse flow alarm is activated during every breath.	If the volume sensor is located in the proximal end of the "Y" connector in the patient circuit, the alarm may sound for each breath.	Either locate sensor in the distal position of the expiratory limb, (see "2/Getting Started") or use the setup page to disable the reverse flow alarm. (see section "5/Operating the Ventilator").
	Volume sensor cartridge is connected backwards to sensor clip.	Correctly connect the clip to the volume cartridge.(see "2/Getting Started")

Troubleshooting ventilator failure messages

Ventilator failure messages can indicate anything from a defective electronic chip to excessive pressure in the ventilator's driving gas supply. Do not attempt to use the ventilator while a ventilator failure message is displayed. And, even if no ventilator failure message is displayed, do not use the ventilator if you suspect a malfunction has occurred.

IMPORTANT

If the ventilator experiences extreme electrical interference, it may interrupt mechanical ventilation. If this interruption occurs, the ventilator generates an internal reset function and resumes normal operation after two (2) seconds. For situations where continuous electrical interference is experienced by the ventilator, causing a continuous interruption, the ventilator's internal reset repeats until the interference ceases.

If the electrical interference is continuously present and mechanical ventilation is interrupted for approximately 30 seconds, the ventilator produces a continuous beeping audio alarm. Manual ventilation of the patient must be performed while the mechanical ventilation is interrupted. When the electrical interference ceases, the continuous beeping audio alarm can be silenced only by turning, as applicable, the ventilator or anesthesia machine power switch OFF and after five seconds back ON.

WARNING: Manual ventilation must be performed when electrical interference causes interruption of ventilator delivered mechanical ventilation. Manual ventilation must be continued until the ventilator resumes normal operation or an alternate ventilator/anesthesia system can be used.

WARNING: The use of electrosurgical units or other devices that radiate high-intensity electrical fields can affect the operation of the ventilator and monitors attached to the patient. Maintain as much distance as possible between the electrosurgical leads and the cables to the flow and oxygen sensors. Do not drape the electrosurgical leads across the absorber or the anesthesia machine. Do not let the electrosurgical leads rest on any surface of the anesthesia system. Constant surveillance of all monitoring and life support equipment is mandatory whenever electrosurgical devices are in operation, on, or in the vicinity of the patient.

If your ventilator displays a ventilator failure message, please note the failure number, any other symptoms, and any corrective actions you took, then call trained service personnel.

Ventilator failure messages

Vent fail message	Possible cause
VENT FAIL 0 !	Electronic failure
VENT FAIL 1 !	Electronic failure
VENT FAIL 2!	Electronic failure
VENT FAIL 3 !	Electronic failure
VENT FAIL 4 !	Regulated gas pressure more than 30 psig (210 kPa)
VENT FAIL 5 !	~ power failure and backup-battery voltage low
VENT FAIL 6 !	Flow valve circuit failure
DRIVE CKT OPEN !	Exhalation valve circuit failure or Bag/APL switch in wrong position
VENT FAIL 8 !	Gas inlet circuit failure
VENT FAIL 9 !	Electronic failure
VENT FAIL 10 !	Electronic failure
VENT FAIL 11 !	Electronic failure
VENT FAIL 12 !	Electronic failure
VENT FAIL 13 !	Electronic failure
VENT FAIL 14 !	Electronic failure

Vent fail message	Possible cause
VENT FAIL 15 !	Auxiliary port selected on Excel dual port system, but French language not selected
VENT FAIL 16 !	Electronic failure
VENT FAIL 17 !	Electronic failure
VENT FAIL 18 !	Electronic failure
VENT FAIL 19 !	Electronic failure
VENT FAIL 20 !	Electronic failure
VENT FAIL 21 !	Electronic failure
HARDWARE ERROR A	Electronic failure
HARDWARE ERROR B	Electronic failure
HARDWARE ERROR C	Electronic failure
SOFTWARE ERROR A	Invalid data detected
SOFTWARE ERROR B	Invalid data detected
SOFTWARE ERROR C	Invalid data detected
SOFTWARE ERROR D	Invalid data detected
SOFTWARE ERROR E	Invalid data detected
SOFTWARE ERROR F	Invalid data detected

Notes:

8/Autoclavable bellows assembly

8.1 Introduction

The Ohmeda Autoclavable Bellows Assembly (ABA) was specifically intended for use with Ohmeda 7000, 7800 ventilators; Modulus II Plus/7810 and Modulus CD/7850 Anesthesia systems. For detailed system information or information on setting up theory of operation and preoperative checkout procedures, see the appropriate section of this O&M manual.

Special note: The ventilator manuals, anesthesia manuals and the appendix of this manual may contain information that pertains to other versions of Ohmeda's bellows assemblies. The information contained in this section pertains only to the Ohmeda ABA and DOES NOT APPLY TO OTHER BELLOWS ASSEMBLY VERSIONS.

8.2 Getting Started

WARNING: Disassembly, reassembly, cleaning and sterilization of the ABA should never be undertaken by any person who has not read this manual thoroughly and clearly understands the text. Failure to be totally familiar with the disassembly and reassembly for the ABA can result in equipment malfunction and injury to the patient.

This unit is not sterile as it is shipped from the factory.

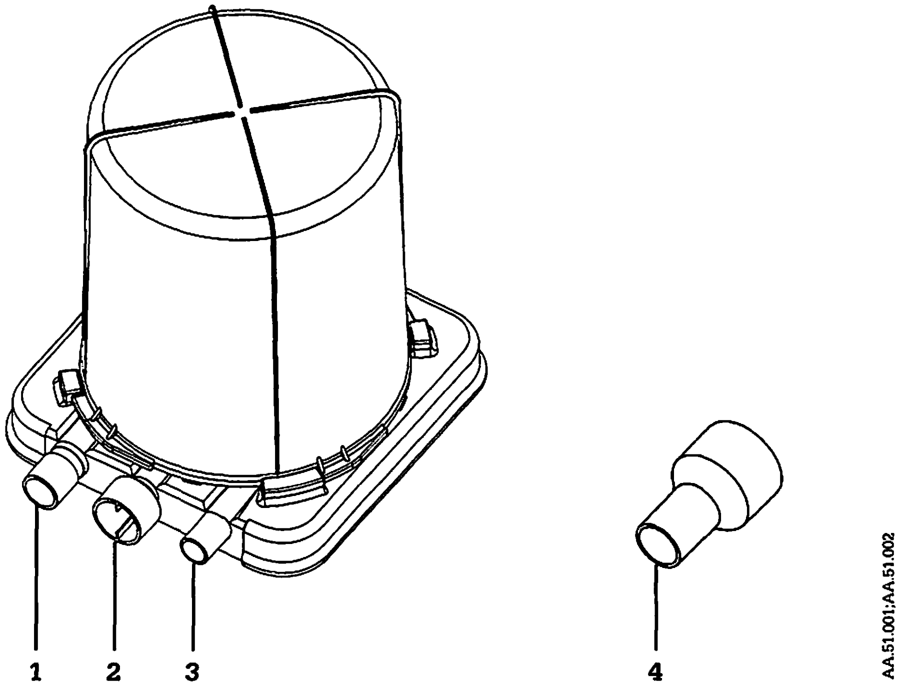
The ABA mounting plate will mount on any Ohmeda 7000 or 7800 series ventilator control module, or in a remote mounting location using the four mounting screws provided. There are several possible orientations for the mounting plate and connection ports.

A. Ventilator Connections

WARNING: Do not connect the 30-mm exhaust port directly to a high vacuum source. The vacuum may remove required gases from the breathing circuit.

8/Autoclavable bellows assembly

Figure 8-1
Port identification and typical adapter.



1. 22-mm port to breathing system
2. 30-mm port waste gas scavenging system
3. 17-mm port drive gas
4. Adapter 30/19 mm

Note: Territorial standards may dictate gas scavenging ports other than 30-mm. Adapters may have been included with your system. Contact your local Ohmeda representative for port conversion information.

WARNING: Disassembly, reassembly cleaning and sterilizing of this ABA should never be undertaken by any person who has not read this section thoroughly and clearly understood the text. Failure to be totally familiar with disassembly and reassembly of the ABA can result in equipment malfunction.

WARNING: Always perform the preoperative checkout procedures before using the system. Failure to ensure proper assembly, setup and operation prior to use may result in injury to the patient.

B. Disassembly

The sequence of the following illustrated procedure is for disassembly of the bellows assembly - reassembly is the reserve of this sequence.

Figure 8-2
Depress lever, remove ABA.

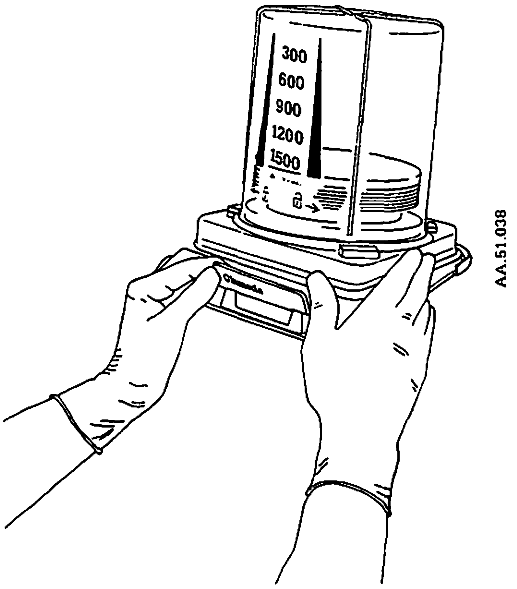
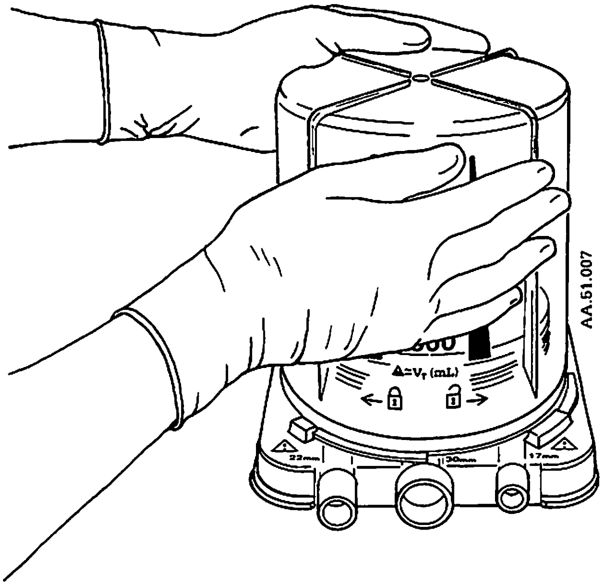

300
600
900
1200
1500
AA.51.038

Figure 8-3
Rotate housing counter-clockwise, lift to release.
Unlock. 🔓

Note: Upon reassembly, ensure that the housing tabs are locked onto the base. Insecure locking will cause unacceptable leaks.


$\Delta = V_T$ (mL)
22mm
30mm
17mm
AA.51.007

8/Autoclavable bellows assembly

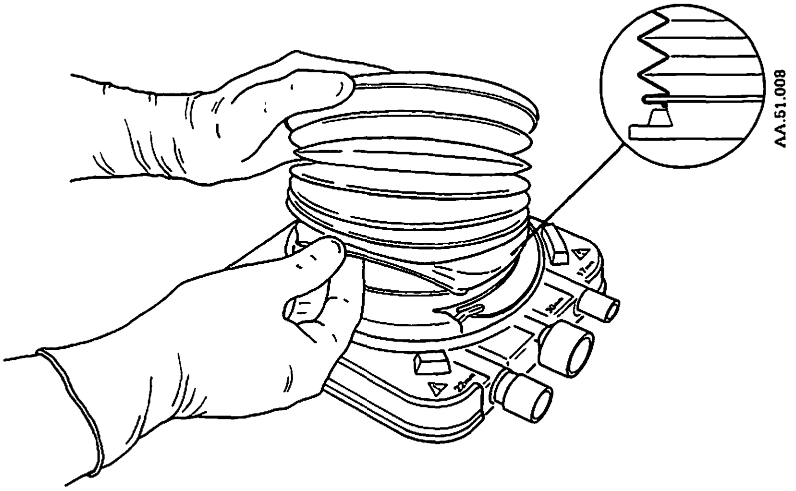


Figure 8-4
Remove bottom convolution of bellows from rim.

Note: Upon reassembly, pull up on the bellows so only one convolution is under the rim. Ensure that the inside ring is secure in the disk groove. Faulty operation could occur with more than one convolution under the rim.

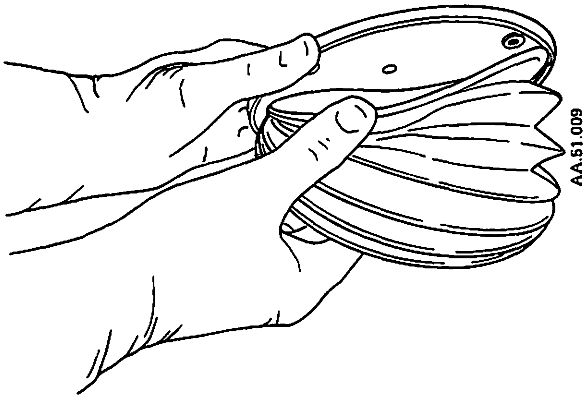


Figure 8-5
Remove disk from bellows.

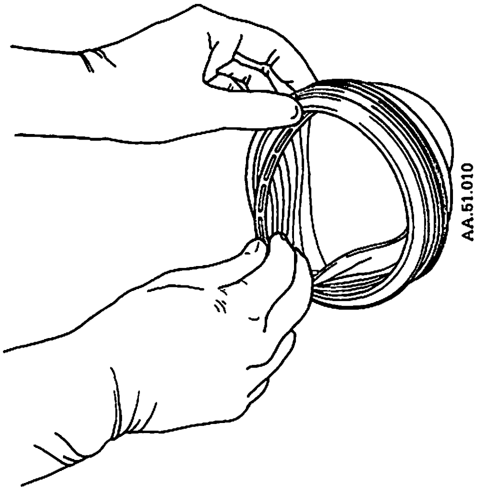


Figure 8-6
Remove inside ring from the top convolution.

Figure 8-7
Push latch toward center, remove rim.

Note: On reassembly you will hear a "click/click" sound, pull up on the rim to ensure it is locked.

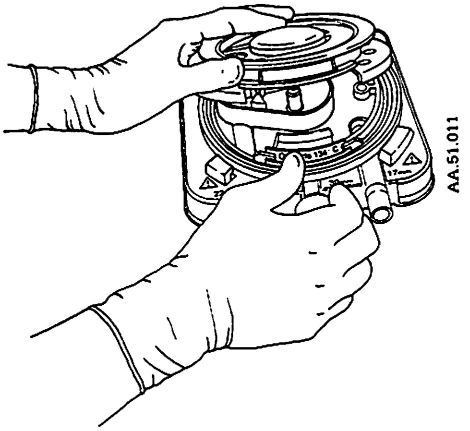


Figure 8-8
Remove pressure relief valve diaphragm and seat assembly. Protect valve seats. Handle the valve seats with care and protect them from damage.

⚠ Do not remove seat from diaphragm.

Note: Reassemble to base with arrows pointed up ⇈

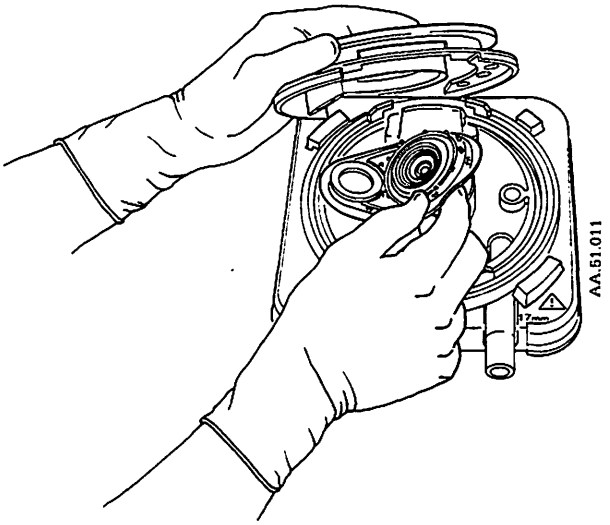


Figure 8-9
Push latch tabs toward center - lift off.

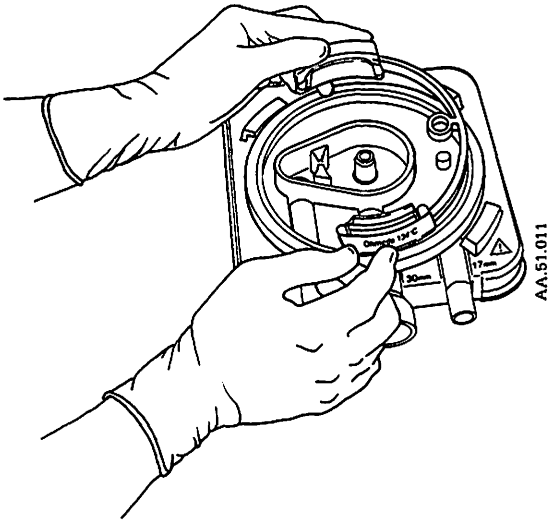
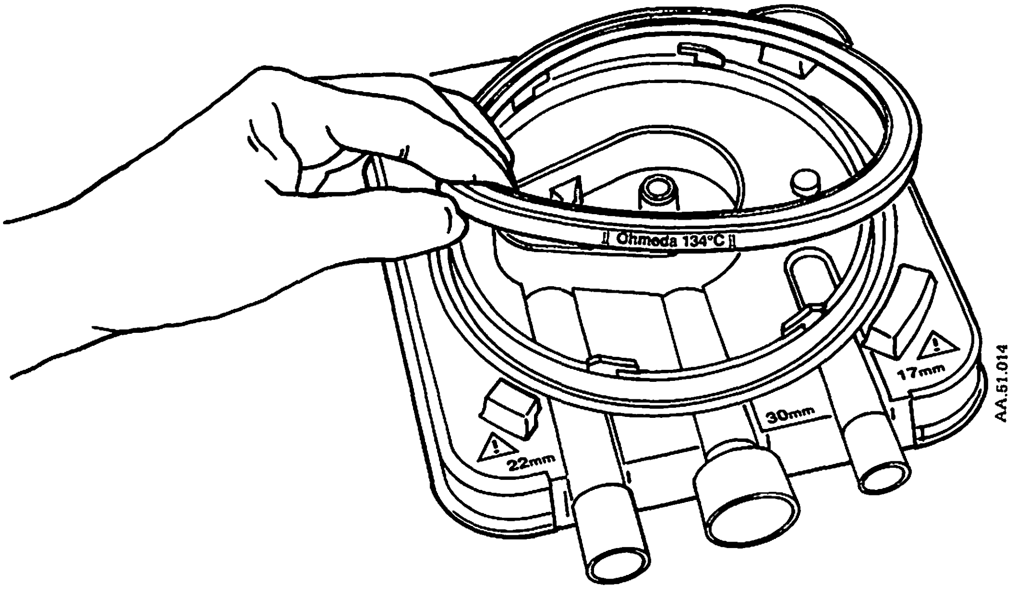


Figure 8-10
Remove seal.



Reassemble to
base with arrows
pointed up ⇈

Reassemble in reverse order.

8.3 Post Assembly Test

WARNING: When occluding the ABA ports for testing do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for obstructions.

WARNING: Always perform the preoperative checkout procedures before using the system. Failure to ensure proper assembly, setup and operation prior to use may result in injury to the patient.

This post assembly test is intended as a quick check for personnel responsible for reassembly, to verify that all components are properly reinstalled after disassembly - IT IS NOT A SUBSTITUTE FOR A SYSTEM PREOPERATIVE CHECKOUT PROCEDURE. If the ABA meets the following post assembly test requirements, remount the ABA to the mounting plate in the system. If it does not, disassemble to ensure reassembly was correct, inspect and replace any damaged parts. See Illustrated Parts List for part numbers.

Figure 8-11
Prior to remounting, hold ABA upright - Occlude 17-mm port.

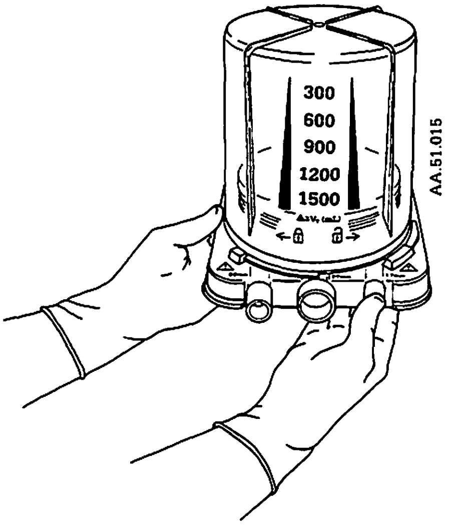

300
600
900
1200
1500
AA.51.015

Figure 8-12
Invert the ABA. Bellows should not fall at a rate of more than 100 mL/min.

If it does, the 17-mm port is not securely occluded, the bellows is not correctly installed, the seal is not properly installed with the groove up or other parts may be damaged.

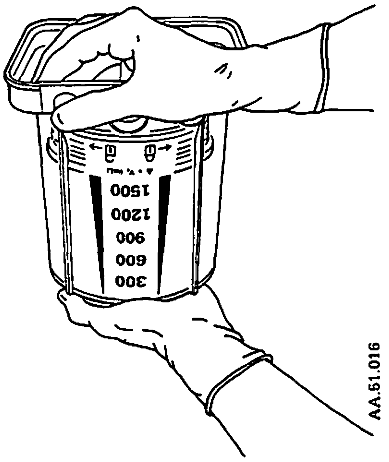
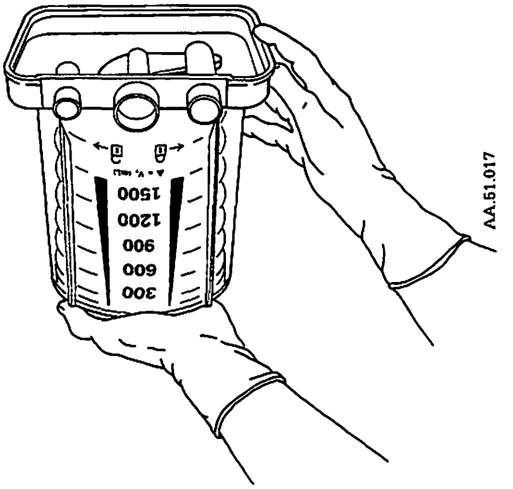

1500
1200
900
600
300
AA.51.016

Figure 8-13
Remove occlusion from the 17-mm port, allow bellows to fully extend, then occlude 22-mm port.


1500
1200
900
600
300
AA.51.017

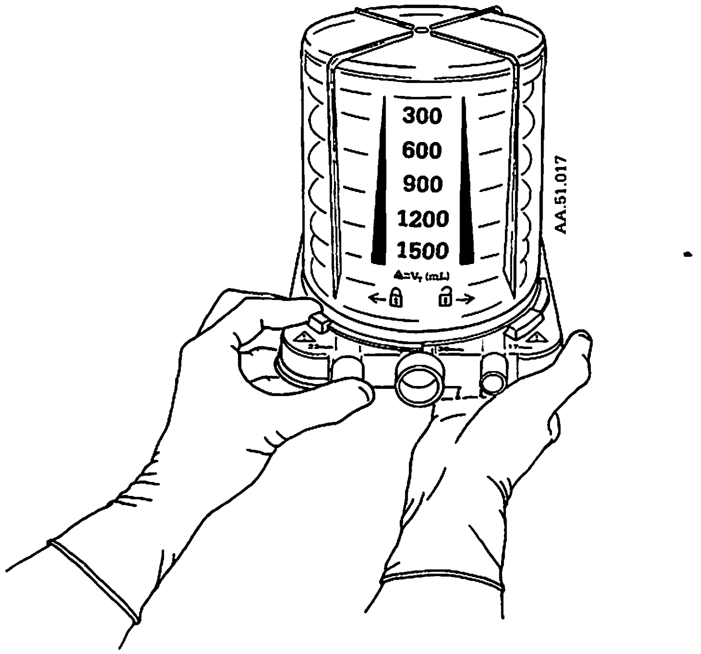


Figure 8-14
Return ABA to upright position. Bellows should not fall at a rate of more than 100 mL/min.

If it does, the bellows or pressure relief valve are not properly installed or other parts may be damaged.

If the ABA meets these post assembly test requirements, remount the ABA to the mounting plate in the system.

- Make Ventilator/Bellows Assembly and breathing system connections.
- Before use, perform preoperative checkout procedures.

8.4 Cleaning and Sterilization

⚠ **WARNING: Disassembly, reassembly cleaning and sterilizing of the ABA should never be undertaken by any person who has not read this section thoroughly and clearly understood the text. Failure to be totally familiar with disassembly and reassembly of the ABA can result in equipment malfunction.**

Use the cleaning and sterilization schedule that is compatible with your institution's infection control and risk management policies. Use methods that are recommended and approved by the manufacturer of the washer and sterilizer.

A. Cleaning

1. Disassemble as explained in Disassembly section and Figures 8-2 through 8-10.

WARNING: Do not remove seat from diaphragm of the pressure relief valve.

2. Protection the parts from damage, gently hand wash or machine spray wash components in hot water using a mild detergent recommended for rubber and plastic. Use of enzyme disinfectant/sterilants are not recommended.

CAUTION: Do not submerse rubber goods for more than 15 minutes - swelling or premature aging could occur.

3. Rinse the assembly components in clean hot water and dry them.

CAUTION: Do not allow the bellows to dry with the convolutions collapsed; hang it up to dry with the convolutions extended by gravitational force. The bellows could be rendered inoperative due to the convolutions sticking together.

4. After the parts are completely dry, inspect them for any damage and reassemble as explained in Disassembly section, Reassembly section and figures 8-2 through 8-10. Perform the post assembly test as shown and explained in Post Assembly Test section and figures 8-11 through 8-14.
5. Connect the bellows assembly to the ventilator and breathing system as explained in the appropriate section of this O&M Manual.
6. Perform the preoperative system checkout procedure.

B. Sterilization

CAUTION: Only parts identified with 134°C markings are autoclavable. Temperatures that exceed 134°C are not recommended due to increased material deterioration caused by excessive heat. Parts that are not autoclavable are identified with the symbol.

The ABA mounting plate and some other components are not autoclavable.

1. Steam autoclaving is the only recommended means of sterilizing the Ohmeda Autoclavable Bellows Assembly.
2. The bellows assembly may be autoclaved as an entire assembly or partially disassembled with the housing removed, if it is inverted so the bellows is fully extended. Or may be autoclaved disassembled as shown and explained in Disassembly section and figures 8-2 through 8-10.

3. After the parts are sterilized, inspect them for any damage and reassemble as explained in Disassembly section, Reassembly section and figures 8-2 through 8-10. It is normal for the bellows and other rubber goods to change color somewhat from steam autoclaving.

4. Perform the post assembly test as shown and explained in Post Assembly Test section and figures 8-11 through 8-14.

5. Connect the bellows assembly to the ventilator and breathing system, see the appropriate section of this O&M manual.

6. Perform the preoperative system checkout procedure.

8.5 Periodic maintenance

WARNING: Do not, under any circumstances, perform any testing of maintenance on medical devices while they are being used on a patient. Possible injury could result.

At a minimum of every 30 days, perform the following to help ensure the timely replacement of components that may have degraded from use and daily cleaning autoclaving and handling. All components of the Ohmeda ABA are considered expendable parts.

Visual inspection

1. Disassemble the ABA from the anesthesia machine.

2. Disassemble the ABA per Disassembly section and figures 8-2 through 8-10.

WARNING: Do not remove seat from diaphragm of the pressure relief valve.

3. Carefully inspect each component for signs of deterioration or damage such as cracks, warpage, tackiness, swelling or other physical changes, and replace as necessary. It is normal for the bellows and other rubber goods to change color somewhat from steam autoclaving.

4. Reassemble and perform the Post Assembly Leak Test per Disassembly section, Reassembly section and Post Assembly Leak Test, see figures 8-2 through 8-14. Connect the ABA back into the anesthesia system and perform the appropriate preoperative checkout procedure.

8.6 Pressure leak test.

Checking the ABA for leakage under pressure (250 mL/min. at 60 cm H_2O) using the breathing system pressure gauge and the anesthesia machine flowmeters. Breathing system leakage is determined prior to connecting the ABA. Repeating the test after the ABA is connected determines the leakage of the ABA unit.

WARNING: When occluding the ABA ports for testing do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for obstructions

A. Bellows Retention Test

1. Occlude the patient connection port ("Y" piece), and exhaust (30-mm) outlet.

2. Set the breathing system to ventilator mode. If you have an Ohmeda GMS Absorber, move the switch to VENT.

3. Inflate the bellows to the top of the housing using the oxygen flush valve. While watching the oxygen flowmeter, increase the pressure on the breathing circuit pressure gauge to 15-cm H_2O.

4. Remove the occlusions from the ports and continue with the following tests.

B. Test the breathing system - ABA out of the circuit.

1. Set the breathing system for the bag mode using the Bag/Ventilator switch if present. Remove the breathing bag and occlude the bag port. Remove any gas sampling adapters or tightly cap off connections.

2. Turn the APL valve fully closed. Turn OFF any other device in the circuit that may leak in this mode at a pressure of 60 cm H_2O. Consult your breathing system operation manual.

3. Turn the anesthesia machine to "Standby" and adjust O_2 to its minimum flow. Turn OFF all other gases.

4. Occlude the patient connection port, e.g., the "Y" piece, while you watch the pressure gauge. Ignore or silence any alarms that may occur during the test. But, quickly unplug the port if the pressure approached 100 cm H_2O.

5. Using the O_2 flow control valve, increase the O_2 flow rate until the pressure approaches 60 cm H_2O. Then quickly reduce the flow rate to match the leak rate so that pressure is maintained at 60 cm H_2O. The pressure will continue to rise if the leak rate of the breathing system is less than the minimum O_2 flowmeter setting.

6. Remove the occlusion from the patient connection port and note the O_2 flowmeter reading as the breathing system's leak rate. Return the O_2 flow to its minimum setting and remove any occlusions made during the test.

B. Test the connected ABA and breathing system

7. Set the breathing system for the ventilator mode so the ABA is in the circuit. Disconnect the drive gas tube from the 17-mm port labeled "Connect to bellows assembly inlet," located on the rear of the ventilator control module, and occlude the disconnected tube.

8. Repeat previous steps 4, 5 and 6.

9. Adding the ABA to the circuit should not increase the leak rate noted in step 6 by more than an additional 250 mL/min. Proceed to step 11 if the leakage is acceptable.

10. An unacceptable leak (higher than noted in step 9) requires repair, do not use the ABA until repairs are made.

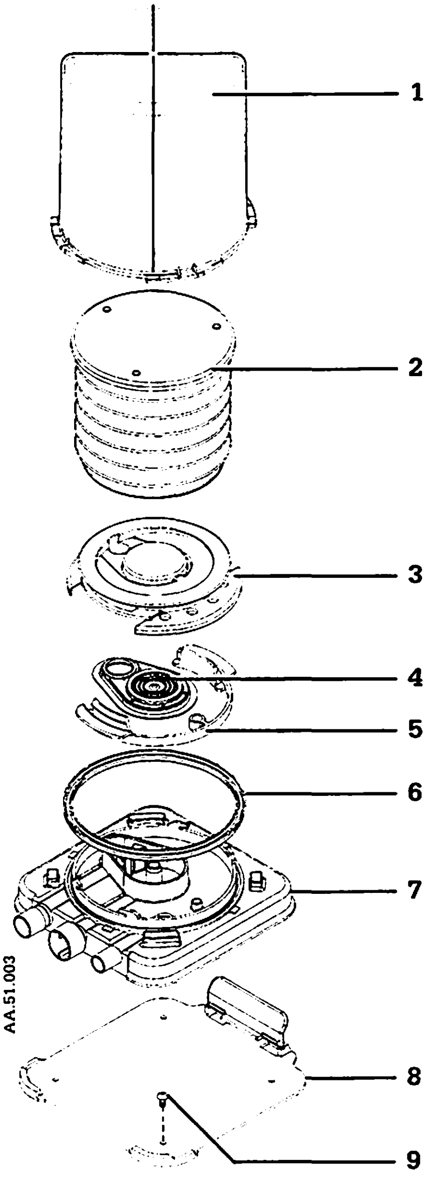
Note: The housing seal, the pressure relief valve, base and tubing are the most likely areas to leak. Systematically replace these parts until the leak is corrected.

11. Unplug the drive gas tube and connect it to the ventilator. Correct any alterations and remove any occlusions made to the breathing system during this test. Perform the preoperative Checkout Procedure.

8.7 ABA Illustrated Parts List

Figure 8-15
Exploded view of
ABA assembly

1. Housing (1500-3117-000)
2. Bellows (1500-3378-000)
3. Rim (1500-3351-000)
4. Pressure relief valve (Diaphragm and seat assembly - 1500-3377-000)
5. Latch (1500-3352-000)
6. Seal (1500-3359-000)
7. Base (1500-3350-000)
8. Mounting plate (1500-3379-000)
9. Mounting screws, 10-32 x 1/2 sst, 4 required, 0140-6631-109



Not Shown
Disc/ring/bumper assembly for bellows (1500-3381-000)

Notes:

9/Appendix

9-A Specifications

The Anesthesia Machine

All specifications are nominal and subject to change without notice.

IMPORTANT NOTICE: The standard Ohmeda Modulus II Plus Anesthesia System has a minimum oxygen flow rate of 200 milliliters per minute. Some systems can be equipped with a low oxygen flow modification kit that allows a minimum oxygen flow capability of 50 milliliters per minute.

Systems with 50 milliliters per minute oxygen-flow

1. Have an oxygen flowmeter module with a range of 50 milliliters per minute to 12 liters per minute,
2. Allow oxygen flow rate adjustments through the entire range,
3. Have a WARNING label affixed to the flowmeter shield that identifies the system as having a minimum oxygen flow rate of 50 milliliters per minute.

Each reference in this manual to the standard 200 milliliters per minute minimum oxygen flow is followed by a bracketed value of 50 milliliters per minute. Use this value if your system has the low flow modification.

WARNING: The Ohmeda Link 25 Proportion Limiting Control System ensures only that oxygen-nitrous oxide mixtures will have a minimum (nominal 25 percent) oxygen concentration. HYPOXIC MIXTURES MAY BE DELIVERED IF GASES OTHER THAN OXYGEN, NITROUS OXIDE AND/OR AIR ARE USED, OR WHEN OPERATING AT LOW OXYGEN FLOW RATES. When using carbon dioxide as an additional gas, make sure the proportions of all gases are carefully adjusted in accordance with accepted clinical practice. Gas mixtures within the breathing system must be monitored when using these gases.

WARNING: The Ohmeda Modulus II Plus Anesthesia System is restricted to use wit nonflammable anesthetic agents.

This manual is representative of the ANSI version of Ohmeda's Modulus II Plus Anesthesia System with built in ventilator/monitor systems. The manual is used in the United States of America as well as Canada, Southeast Asia, South Africa and Japan. The following table provides a matrix of differences between the various machines as they are manufactured to the specifications of the previously listed countries.

Ohmeda Modulus II Plus Anesthesia/7810 Ventilator System model differences and variances by country

	U.S. 3-gas	Canada 3-gas	Canada 4-gas	Japan	SE Asia	South Africa
Ohmeda System No.	1010-9009-000	1010-9008-000	1010-9014-000	1010-9002-000	1010-9006-000	0236-5452-910
3-Gas w/Air	■	■		■	■	
4-Gas w/Air, He			■			
4-Gas Air-pipeline only & CO_2 cylinder only						■
Backlit Flowmeters	■	■	■			■
CSA Approval		■	■			
Gas colors ISO		■	■			■
CEE-22 Outlets					■	■
Pipeline connection	DISS Male	DISS Hand-I-Twist	DISS Hand-I-Twist	DISS Male	DISS Male	DISS Male
Pri. Reg relief valve setting 85 psi (586 kPa)				■	■	■
Pri. Reg relief valve setting 75 psi (518 kPa)	■	■	■			
Primary Regulator Setting at 40 psi (276 kPa)	■	■	■			
Primary Regulator Setting at 50 psi (345 kPa)				■	■	■
Volts alternating current	120 V	120 V	120 V	100 V	220 V	220-250 V
Wall Gas Pressure 50 psi (345 kPa)	■	■	■			
Wall Gas Pressure 60 psi (413 kPa)		■		■	■	■
Warning Labels, French/English		■	■			
Waste Gas Evac System Standard	■	■	■			

Electrical

Maximum Internal Power Requirements– Standard System:	350 W at 100/120 V a-c 50/60 Hz (Includes Ohmeda 7810 Ventilator and all options). See preceding table for system voltages specific to models.

CAUTION: The voltage for this system was set in the factory. Do not change the original factory setting. Other system changes must be made before changing the voltage setting. If the available voltage differs from the voltage setting, call a qualified service representative to make all the required system changes.

Line Voltage Outlets:	7 Amperes maximum available total for all outlets at 100/120 V a-c 3 Amperes maximum available total for all outlets at 220/240 V a-c
Leakage Current:	Less than 100 µA at 100/120 V a-c Less than 200 µA at 220/240 V a-c
Ground Continuity	Equal to or less than 0.10 Ohms
Circuit Breakers:	7A to line voltage outlets; 5A for internal circuitry at 100/120 V a-c 3A to line voltage outlets; 3A for internal circuitry at 220/240 V a-c
Electrical Failure Alarm:	An intermittent alarm sounds for three seconds ON, about five minutes OFF, when line voltage fails or when the internal main power supply fails.

Pneumatics

Oxygen Pressure Sensor Shut Off Valve System:	Pressure Sensor Shut Off Valves shut OFF all other gas flows if oxygen-supply pressure falls to about 20 psig (138 kPa).
Oxygen Supply Failure Alarm:	An alarm sounds continuously when oxygen pressure falls below 28 psig (193 kPa).
Pipeline Supply Pressure:	See chart
Pipeline Inlet Connections:	DISS (diameter index safety system) inlets are standard for oxygen, nitrous-oxide and air connections.
Cylinder Hanger Yokes:	Safety pin-indexed, locking-gate style requiring CGA standard medical-gas cylinders with pin-indexed, post-type valves. Built-in check valves minimize loss of cylinder gas.

Cylinder Pressure Regulators:	See chart
Gas Pressure Gauges:	Gauges have white on black, dual-scale faces within color coded and labeled identification plates. Cylinder gauge scales range from 0 to 3000 psig (0 to 20,000 kPa). Pipeline gauge scales range from 0 to 100 psig (0 to 700 kPa).
Safety Relief Valves:	See chart
Oxygen Flush:	Recessed, self-closing push button provides a flow of 45-75 Liters per minute when fully depressed.

Calibrated Ranges Of Flowmeters

Oxygen, Double Tube:	200 (or 50) to 650 mL/min and 700 mL/min-12 L/min
Nitrous Oxide, Double Tube:	50 to 650 mL/min and 700 mL/min to 12 L/min
Air (optional):	1-15 L/min
Carbon Dioxide (optional):	20-700 mL/min
Heliox	1-15 L/min
Flowmeter Accuracy (at 740 mm Hg, 21°C):	±2.5% of reading at flow rates 100 milliliters per minute and over, and ±5% of reading for flow rates below 100 milliliters per minute.

Ohmeda Link 25 Proportion Limiting Control System

Provides nominal minimum 25% oxygen concentration for gas mixtures containing only oxygen and nitrous oxide.

Minimum Oxygen Flow

The oxygen flow-control valve is set to deliver a minimum flow of 200 milliliters per minute {50 milliliters per minute} (nominal) when the system master switch is set to ON.

Vaporizer Manifold

The vaporizer manifold can accommodate up to three Ohmeda Tec 4, Tec 5 or Tec 6 Vaporizers.

Outlet Relief Valve

The anesthesia machine is equipped with an internal relief valve set to open at a pressure of 120 to 150 mm Hg.

Gas Evacuation System

Can be used in either active or passive mode.

Positive pressure relief:	set between 1.5 and 4.0 cm H_2O at a flow rate of 60 ± 2 L/min.
Negative pressure relief:	set not to exceed 0.25 cm H_2O at a flow rate of 15 L/min.
Connection ports:	Three 19-mm male
Reservoir:	Three liter reservoir bag

Gas Machine Physical Characteristics

Weight:	365 lb. (166 kg) (without optional equipment)	
Weight Added by Options:	Third Gas Circuitry:	11 lb.(5 kg)
	One Vaporizer:	17 lb.(7.6 kg)
	Ohmeda GMS Absorber:	21 lb.(9.5 kg)
	Ventilator:	19 lb. (8.5 kg)
	Monitor weights vary. Check the weight specification for each monitor in the system and add the monitor weights to the total.	
Height:	61 in. (155 cm)	
Width:	34 in. (87 cm)	
Depth:	25.2 in.(64 cm)	
Stationary Shelf:	Height from Floor:	50 in.(127 cm)
	Maximum Shelf Load:	25 lb.(11.3 kg)
	Size:	14.7 x 12 in.(37 x 30 cm)
	Usable Height:	10 in.(25 cm) minimum; 10.5 in.(27 cm) maximum
Tilting (Top) Shelf:	Height from Floor (horizontal position) :	61.1 in. (255.3 cm)
	Maximum Shelf Load:	60 lb. (27.2 kg)
	Size:	32.4 x 15 in. (38 x 82 cm)
Table top:	Height from Floor:	32.5 in. (82.5 cm)
	Size:	25 x 15 in. (68.5 x 38.1 cm)
Drawer Cabinet:	Contains three 14 in. (35.5 cm) deep, 15 in. (38 cm) wide, ball-bearing slide drawers.	
	Bottom drawer height:	8 in. (20.3 cm) high.
	Two top drawers heights:	4 in. (10.1 cm) high.
Absorber Post Mounting Assembly:	Absorber Swivel Arm Length:	14 in. (35.5 cm)
	Push Button Vertical Adjustment:	10 to 26 in. (25.4 to 66 cm) from floor.
Casters:	5 in. (12.7 cm) diameter; non-conductive; front casters have brake lock.	
Common Gas Outlet:	Equipped with a latching, positive engagement, bayonet-type connector. The common gas outlet connector also accepts standard 22-mm ID or 15-mm OD conical, friction-fit connectors.	

The Ventilator

Electrical

Power Consumption:	15 watts maximum
Display Type:	Liquid Crystal Display
Circuitry:	Microprocessor-controlled. RS232C serial output

Controls

Control	Range	Display Resolution
Tidal Volume:	50-1500 mL	From 50 to 100 mL: 2 mL increments From 101 to 250 mL: 5 mL increments From 251 to 1000 mL: 10 mL increments From 1001 to 1500 mL: 20 mL increments
Rate:	2-100 B/min	1 B/min increment
Inspiratory Flow:	10-100 L/min	Resulting I:E Ratio: 1:0.5 minimum, 0.5 resolution
Inspiratory Pressure Limit:	20-100 cm H_2O	1 cm H_2O increment
Inspiratory Pause:	25% T_I	

Monitoring

Oxygen Monitoring

Display:	Range:	0 to 110 percent oxygen
	Resolution:	1 percent of full scale
	Update:	Once per second
Sensor:	Sensor type:	Galvanic fuel cell
	Response time:	Typically 20 seconds for 90% of total change in O_2 concentration at 25°C (77°F).
	Drift:	±1 percent over 8 hour period
	Linearity:	±3% of full scale (Monitor only; sensor cartridge contributes ±2.5%
	Life:	12 months typical (assuming average O_2 equal to 50% concentration at 25°C (77°F)
	Low Oxygen Alarm Limit:	18-99%, 1% increment
	High Oxygen Alarm Limit:	19-99%, 1% increment (disabled when set to zero)

Volume Monitoring

Display range	Tidal Volume:	0 to 9999 mL, 1 mL resolution
	Minute volume:	0.0 to 99.9 L, 0.1 L resolution
	Breath Rate:	2 to 99 Breaths per minute, 1 B/min resolution

Accuracy:	Tidal Volume:	300 mL to 1.5 L range: ±8 percent or ±40 mL (whichever is greater)
	50 mL to 299 mL range:	±20 percent or ±20 mL (whichever is greater)
Sensor:	Type: on,	Expendable turbine vane flow cartridge with clip-heated, optical coupler
	Turbine Resistance:	Approximately 1 cm H_2O at 60 L/min
	Flow Range:	3 to 600 L/min
	Repeatability, same cartridge:	At a constant flow rate, ±5 percent of original reading
	Different cartridges:	±35 mL over a range of 0.1 to 3.0 L/min
	Dead air space:	6 to 10 mL depending upon breathing circuit adapters
Minimum breath:	Volume:	20 mL
	Flow:	≥6.6 L/min when Tidal Volume dial set to 300 mL or more. ≥2.0 L/min when Tidal Volume dial set to less than 300 mL.
Breathing circuit connections:	Inlet:	22 mm male tapered or 15 mm female tapered with tracheal tube adapter
	Outlet:	22 mm female tapered
	Low Minute Alarm Limit:	0-9.9 liters per minute, 0.1 liter increment

Airway Pressure Monitoring

Pressure Transducer Range:	-20 to +120 cm H_2O, ±3 cm H_2O
Response Time:	10 milliseconds
Accuracy:	±3 cm H_2O over the range of -20 to 120 cm H_2O
High Pressure Alarm Limit:	20-100 cm H_2O, 1 cm H_2O increment
Sustained Pressure Alarm Limit:	10-30 cm H_2O, 1 cm H_2O increment
Sub-atmospheric Pressure Alarm:	less than -10 cm H_2O

Ventilator Performance Characteristics

Driving Gas Supply Requirements:	35 to 80 psig at 100 Liters per minute continuous flow at inlet to ventilator; 50 psig nominal at pipeline.
Ventilator Compliance:	Compliance for connecting hoses are not included in these compliance specifications.
	Adult Bellows: Approximately 3 mL per cm H_2O
	Pediatric Bellows: Approximately 1.5 mL per cm H_2O
Ambient Operating Temperature Range:	50 to 104°F (10 to 40°C)
Ambient Operating Humidity Range:	0 to 100 percent Relative Humidity (non-condensing)
Ambient Operating Pressure:	500 to 800 mm Hg
Altitude Compensation:	Sea level to 3000 meters 1 foot = 0.3048 meters

Ventilator Physical Characteristics

	Bellows Assembly	Control Module
Weight:	4.0 lb (1.8 kg.)	11.2 lb. (5.1 kg)
Depth:	8.0 in.(20.3 cm)	10.7 in.(27.3 cm)
Width:	7.5 in.(19.0 cm)	8.5 in.(21.6 cm)
Height:	9.0 in.(22.9 cm)	5.2 in.(13.3 cm)

Approximate Tidal Volume Scale Range:	Bellows Housing: Adult: 1600 mL maximum Pediatric: 300 mL maximum
Storage Requirements:	Temperature: -4 to +158°F (-20 to +70°C) Humidity: 0 to 100 percent relative humidity (non-condensing)

9-B Optional Accessories

Gas Machine

Description	Stock Number
Add-on yoke, oxygen (field installed)	0236-6114-810
Add-on yoke, nitrous oxide (field installed)	0236-6114-811
Standard suction regulator kit	1010-8015-000
Free flow regulator kit	1010-8016-000
Suction regulator bracket (only) kit	1010-8021-000
Touchup paint, dark blue for machine frame	0220-0208-300
Touchup paint, mid blue for machine drawers	0220-0209-300
Touchup paint, white for monitor pod	0220-0211-300

Absorber Accessories

Description	Stock Number
GMS PEEP Valve kit for Ohmeda GMS Absorber	0216-6781-870
Bain circuit adapter for Ohmeda GMS Absorber	0236-0483-800
Bain circuit adapter non-GMS Absorber	0216-6498-802

Bellows Assemblies And Accessories

Description	Stock Number
Pediatric bellows assembly w/GMS mount	0236-0504-801
Pediatric bellows assembly	0219-7520-871
Remote bellows mounting kit, dovetail mount	1001-8953-000

Optional Monitors And Monitor Accessories

Description	Stock Number
Ohmeda 5210 CO_2 Monitor (field installed)	0236-6120-870
Ohmeda 3710 Pulse Oximeter (field installed)	0236-6125-870
Ohmeda 2120 Non-Invasive Blood Pressure Monitor (field installed)	0236-6127-870
Monitor pod blank cover	0236-0321-800
Monitor pod bin	1010-8103-000
Manual blood pressure gauge, large case (mounts in monitor pod) (field installed)	0236-6128-870
Manual blood pressure gauge, small case (mounts next to pod)	0236-6148-870
Inflation system for manual blood pressure gauge (adult)	0211-1100-300
Oxygen sensor assembly w/6 ft cord	0237-2030-700
Oxygen-sensing tee (22-mm Tee manifold) for non-Ohmeda GMS Absorber	0212-0763-100

Waste Gas Scavenging Interface Valve Assembly Supplemental Parts

Description	Stock Number
Tubing, Corrugated, w/19-mm bushings 18" long	0225-0810-700
Tubing, Corrugated, w/19-mm bushings 24" long	0225-0809-700
Tubing, Corrugated, w/19-mm bushings 60" long	0225-0808-700
Tubing, Corrugated, w/19-mm bushings 90" long	0225-0807-700
Cap for 19-mm connector	0203-0142-300
Reservoir bag, three-liter w/19-mm bushing	0225-3212-700
19-mm exhaust grille adapter assembly	0219-1291-800

WARNING:After installing any repair, replacement or accessory items, perform the Preoperative Checkout Procedures before using the system.

9-C Replaceable Parts Description Stock Number

Monitoring

Description	Stock Number
Volume sensor clip	0237-2226-700
Volume sensor cartridges (10)	0237-2228-870
Pressure sensing tube, 8' long	6026-0000-014
Pressure-sensing tee (patient-circuit adapter) for non-Ohmeda GMS Absorber	6050-0000-456
Oxygen sensor extension kit, 6 ft cord	0237-2040-880
Oxygen cartridge	0237-2034-700
Oxygen probe (without cartridge)	0237-2030-700
Oxygen probe, front housing only (w/ O-rings)	0237-2035-800
Oxygen probe O-ring (outside)	0210-0503-300
Oxygen probe O-ring (inside)	0210-0499-300
Oxygen-sensing tee (22-mm Tee manifold) for non-Ohmeda GMS Absorber	0212-0763-100

Bellows Assembly

Description	Stock Number
Adult bellows	0229-1013-700
Adult bellows housing	0229-0014-300
Pediatric bellows	0229-1018-700
Pediatric bellows housing	0229-0034-300
Thumbscrew (bellows assembly mounting, all)	0400-3524-300
Thumbscrew (pressure relief valve, all)	0400-3507-300

Autoclavable Bellows Assembly
See section 8.7 for illustrated parts list

Anesthesia Machine

Description	Stock Number
Gas yoke strainer	0206-2806-725
Yoke plug	0206-7129-525
Yoke gasket	0210-5022-300
Yoke tee-handle screw	0219-3372-600
Vac Kote	0220-0091-300
KRYTOX	1001-3854-000

9-D Monitoring Locations On Absorbers Other Than Ohmeda GMS

WARNING: All CAUTIONS, WARNINGS and some notes in the body text of this manual also pertain and are applicable to other Ohmeda absorbers.

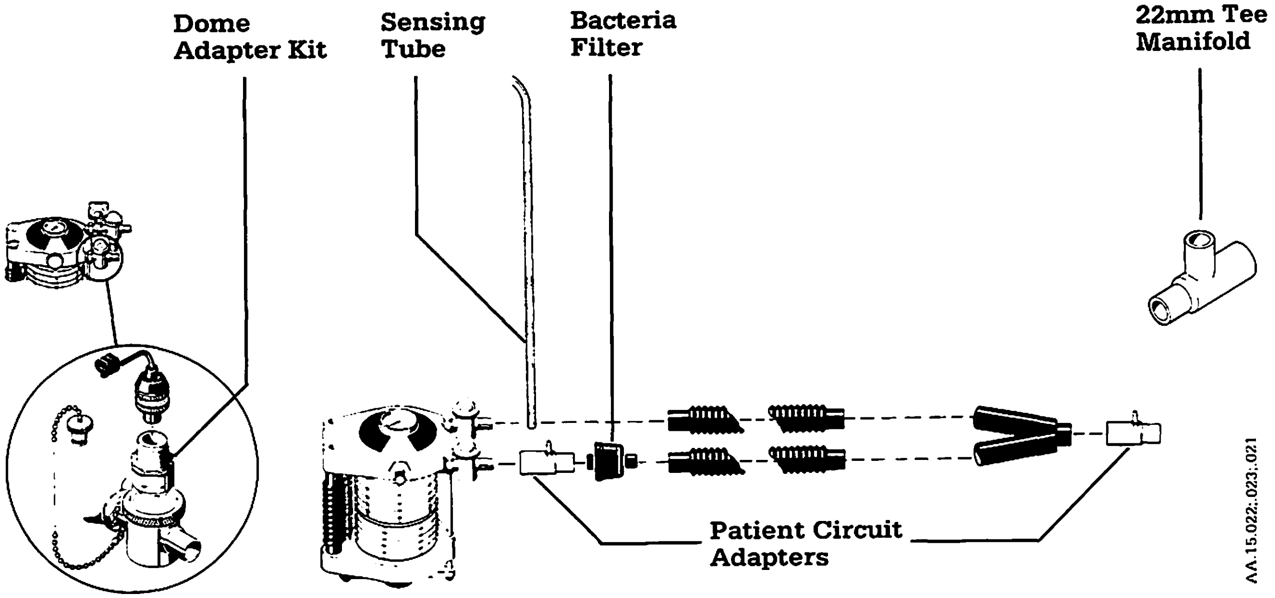
WARNING: When used, the oxygen sensor adapter and the pressure-sensor's patient-circuit adapter must be connected to the inspiratory side of the breathing system. If these devices are not correctly connected to the inspiratory side of the breathing system, oxygen and pressure monitoring and related alarms will not function properly.

WARNING: Proper placement of the pressure sensing tee is very important. The tee must be installed with the tee nipple pointing upward. Improper placement could result in accumulation of condensate in the pressure sensing line and inaccurate pressure readings.

The Ohmeda GMS Absorber includes ports that connect both the oxygen sensor and the pressure-sensing tube directly to the inspiratory side of the breathing system. If your system does not include an Ohmeda GMS Absorber, you must use optional, Ohmeda adapters to connect these devices to the breathing system's inspiratory limb.

To provide a port for the oxygen probe, either use a 22-mm Tee manifold (stock number 1500-3115-000 or, for Ohmeda model 20 and 21 absorbers, use a dome adapter kit (stock number 0236-0035-800). To provide a tap into the inspiratory limb for the pressure monitoring, use a patient circuit adapter (stock number 0219-7547-700).

Figure 9-1
Monitoring adapters for alternate devices

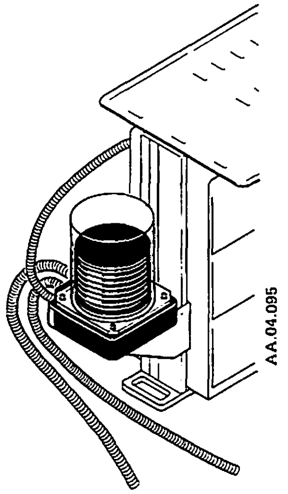


9-E Connecting A Remotely Mounted Non-ABA Bellows Assembly

If you do not use an Ohmeda GMS Absorber, or if you do not use the absorber interface manifold to mount the bellows assembly to the Ohmeda GMS Absorber, you must use tubing to connect the absorber to the bellows assembly.

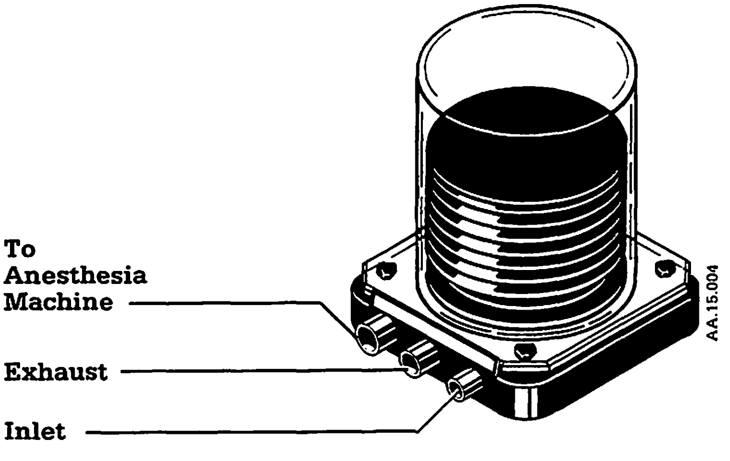
1. Use 15-mm tubing to connect the bellows assembly's port labeled "Inlet" to the control module's drive gas outlet labeled "Connect To Bellows Ass'y Inlet."

Figure 9-2
Remotely mounted bellows



2. Use 22-mm, corrugated tubing to connect the bellows assembly's port labeled "To Anesthesia Machine" to the absorber's ventilator port.
3. Use 19-mm, yellow-banded, corrugated tubing to connect the bellows assembly's port labeled "Exhaust" to the gas scavenging system.

Figure 9-3
Bellows assembly's ports



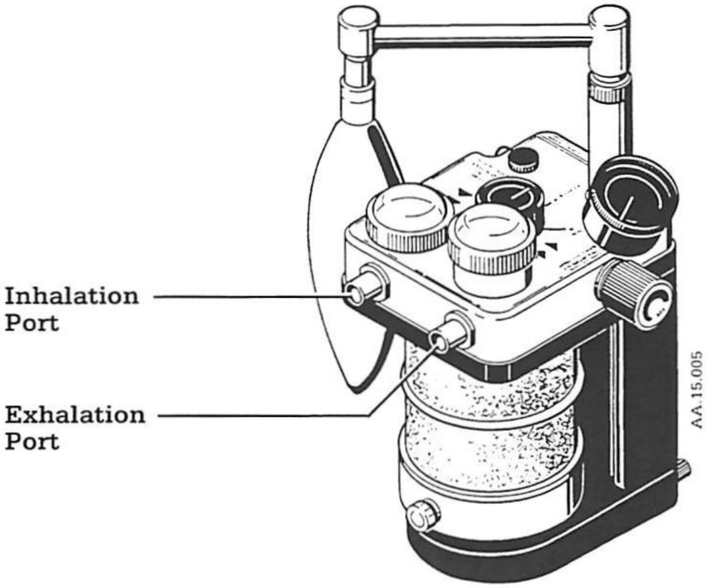
9-F Checking The Absorber Pressure Gauge Location

For pressure monitoring to function correctly, the distal-sensing tee must connect to the inspiratory side of the breathing system. Although all Ohmeda GMS Absorbers manufactured after January 1, 1986 have their pressure gauges connected to the inspiratory side, certain older, unmodified Ohmeda GMS Absorbers have their pressure gauges connected to the expiratory side of the breathing system. If you are not sure that your absorber's pressure gauge—sensing location—is in the inspiratory side of the breathing system, perform the following test.

1. Use your hand to cover the end of the absorber's inhalation port.
2. Press the oxygen flush button for about three seconds to pressurize the circuit.
3. If the pressure gauge shows a pressure increase, the gauge is in the inspiratory side of the breathing system and it may be used as the inspiratory-sensing location for the Ohmeda Modulus II Plus Anesthesia System.

If the gauge does not show a pressure increase, it is not connected to the inspiratory side. Contact Ohmeda to have trained service personnel modify your absorber for use of the patient circuit adapter described in appendix D

Figure 9-4
Absorber's ports



9-G Ventilator communications protocol

For remote recording, a 25-pin female "D" type connector on the ventilator's rear panel provides access to an RS232C serial port, which conforms to the Ohmeda standard communications protocol.

WARNING: Writing to the ventilator's RS232 port can alter the operation of the ventilator's software, which may result in unpredictable performance. Do not alter the ventilator's hardware or software.

CAUTION: Interconnect cables must be unplugged and removed from the RS232 port when peripheral equipment is disconnected. DO NOT leave unattached cables hanging from the ventilator's RS232 port.

The connector's assigned pin outs conform to DTE (Data Terminal Equipment) specifications and is listed below.

25 pin female D connector
pin 2 - transmit data (transmitted from ventilator)
pin 3 - receive data (received by ventilator)
pin 7 - signal ground

The RS232 data format for this protocol is summarized as follows:

Signal Levels:	±5 volts minimum
Baud rate:	1200 baud
Character Code:	7-bit ASCII
Data bit format:	(1) start bit, logic 0 (7) data bits (1) odd parity bit (1) stop bit, logic 1

When the ventilator is first turned ON , the default transmission mode is set to "AUTO," the data format mode is set to "PRINTER," and the checksum mode is "disabled."

Two standard forms of the device commands are shown below and detailed in the following sections.

<ESC>VTxc<CR>

where:

<ESC>VT = header
x = command
c = checksum
<CR> = terminator

<ESC>VTxaac<CR>

where:

<ESC>VT = header
x = command
aa = parameter
c = checksum
<CR> = terminator

The header consists of the ASCII escape character (27 decimal) followed by the device designator for the 7810 Ventilator, "VT." The command terminator for all commands is an ASCII carriage return (13 decimal). If the checksum is enabled, a 7-bit checksum (twos complement of the sum of the transmitted bytes) is included before the command terminator at the end of the device command. If not, an ASCII space character is included.

Device Commands—sent to ventilator

Data Transmit Mode Select Commands

<ESC>VTXc<CR>	Auto mode command (also selects printer data format). Causes ventilator to output data at each breath or every 10 seconds.
<ESC>VTSc<CR>	Slave mode command (also selects compressed data format). Ventilator outputs data when requested by communications device using send all data command.

Data Format Mode Select Commands

<ESC>VTPc<CR>	Printer mode command (default at turn ON) Ventilator outputs data in a printer format, a 75 byte frame.
<ESC>VTQc<CR>	Compressed mode command Ventilator outputs data in a compressed measured-and-status data format, a 58 byte frame.

Data Request Command

<ESC>VT?c<CR>	Send all data command. This command is active in slave mode only, and requests a data and status frame from the ventilator.

Front Panel Control Commands

<ESC>VTCSc<CR>	Silence all alarms command. The ventilator responds just as if the front panel alarm reset switch had been pressed.

Checksum Control Commands

<ESC>VTEc<CR>	Enable checksum command. This command invokes checksum mode.
<ESC>VTDc<CR>	Disable checksum command. The checksum byte will be ignored in this mode (but must be accounted for in the command string). This is the default mode at power ON. (Checksum byte cannot be a <CR> character)

Device Responses—sent back by ventilator

:VTYc<CR>	Acknowledge Only Response: For valid commands, other than send data or reset all alarms commands, the ventilator will respond by transmitting a positive acknowledge response.
:VTNc<CR>	Negative Acknowledge Response: For unrecognized or invalid commands, or when a valid command is not allowed, the monitor will respond by transmitting a negative acknowledge response.

:VTRc<CR>	Alarm Silence Switch Pressed Response: For valid reset all alarms commands and when the front panel alarm reset switch is pressed, the ventilator will respond with an alarm silence switch pressed response if no alarms are active or if all alarms are silenced.

Format for data in compressed mode

Measured Data Response :VTDaaaabbbbdddeeefffggghhhic<cr>

aaaa	measured tidal volume	mL, ?, -
bbbb	measured minute volume	L*100, ?, -
ddd	measured respiratory rate	B/min, ?, -
eee	measured oxygen level	% O_2 (0-255)
fff	measured max + pressure	cm H_2O, ?
ggg	measured inspiratory plateau pressure	cm H_2O, ?,-
hhh	measured minimum pressure	cm H_2O, ?
i	measured data status	01xxxxxx (Fifth "x"from left = 0 = normal breath, 1 = sigh breath. Sixth "x" = 0=10 sec data, 1=new breath data.)
c	checksum	

Status Data Response :VTQaaaabbbdddeeeefffgghhiijjqqqqqqc<cr>

aaaa	set tidal volume	mL
bbb	set respiratory rate	B/min
ddd	set inspiratory flow	L/min
eeee	set I:E ratio	1:eee.e (not rounded)
fff	set peak pressure limit	cm H_2O,
gg	set sustained pressure alarm limit	cm H_2O
hh	low minute volume alarm limit	liters*10
ii	low oxygen alarm limit	% O_2
jj	high oxygen alarm limit	% O_2
qqqqqq	status	
c	checksum	

Each entry is zero filled, right justified (i.e. aaaa = 0095). (1) Status bytes (bit set = condition active): Status bits are latched in the in auto mode to record transient alarms.

Status Bit	Byte 1
D0	high O_2 alarm
D1	low O_2 alarm
D2	apnea alarm
D3	low patient $\dot{V}_E$ alarm
D4	high pressure alarm
D5	low pressure alarm
D6	1

Status Bit	Byte 2
D0	sustained pressure alarm
D1	sub-atmospheric pressure alarm
D2	AC fail (primary supply voltage low)
D3	low battery alarm
D4	O_2 Limit set error
D5	vent setting range error
D6	1

Status Bit	Byte 3
D0	O_2 sensor failure alarm
D1	volume sensor failure
D2	maximum pressure > 60 cm H_2O
D3	reverse flow
D4	low gas supply pressure alarm
D5	apnea alarm off
D6	1

Status Bit	Byte 4	
D0	A/D conversion failure	VENT FAIL 0
D1	CPU failure	VENT FAIL 1
D2	ROM checksum failure	VENT FAIL 2
D3	RAM write/read failure	VENT FAIL 3
D4	gas supply > 207 kPa (30 psig)	VENT FAIL 4
D5	power loss	VENT FAIL 5
D6	1	

Status Bit	Byte 5	
D0	flow output incorrect or continuously on	VENT FAIL 6
D1	Exh. valve not on/off in insp/exp	DRIVE CKT.OPEN
D2	gas supply control solenoid not on	VENT FAIL 8
D3	D/A write/read failure	VENT FAIL 9
D4	pressure transducer board failure	VENT FAIL 10
D5	positive analog supply voltage out of range	VENT FAIL 11
D6	1	

Status Bit	Byte 6	
D0	flow table values 0,FF or non-increasing	VENT FAIL 12
D1	inspiratory pause on	
D2	volume monitor standby	
D3	ventilation switch on	
D4	volume sensor cartridge coasting (end of breath not detected)	
D5	alarms are silenced	
D6	1	

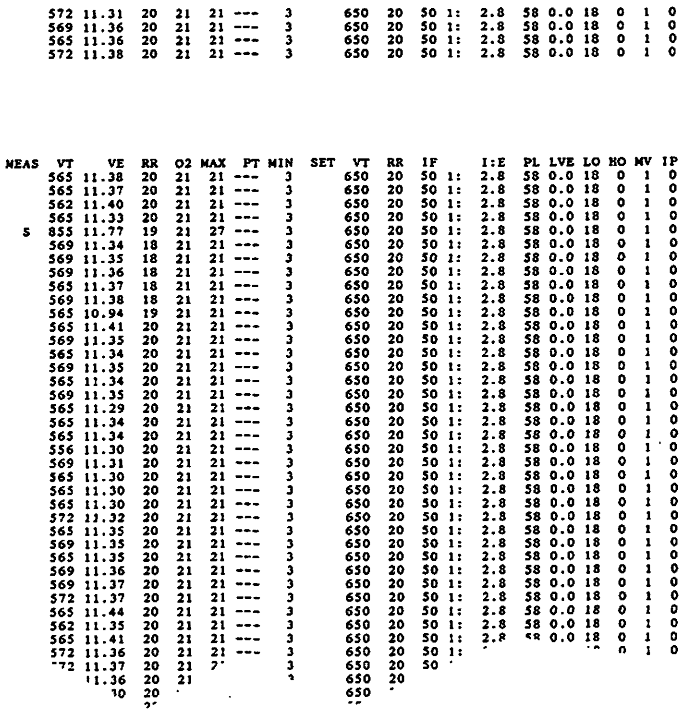


Figure 9-5
Printed sample of serial output

```
      572 11.31  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.36  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.36  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      572 11.38  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0




MEAS  VT     VE  RR  O2 MAX  PT MIN  SET  VT  RR  IF     I:E  PL LVE LO HO MV IP
      565 11.38  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.37  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      562 11.40  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.33  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
   5  855 11.77  19  21  27 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.34  18  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.35  18  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.36  18  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.37  18  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.38  18  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 10.94  19  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.41  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.35  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.34  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.35  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.34  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.35  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.29  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.34  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.34  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      556 11.30  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.31  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.30  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.30  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.30  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      572 11.32  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.35  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.35  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.35  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.36  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      569 11.37  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      572 11.37  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.44  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      562 11.35  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      565 11.41  20  21  21 ---   3      650  20  50 1:  2.8  58 0.0 18  0  1  0
      572 11.36  20  21  21 ---   3      650  20  50 1:               0  1  0
       72 11.37  20  21               3      650  20  50
          11.36  20  21                      650  20
             10  20                          650
```

Format for data in printer mode
Output format
Heading frame (including 6 blank lines):

<LF><CR><LF><CR><LF><CR><LF><CR><LF><CR><LF><CR><LF><CR>

S^{sp}MEAS^{spsp}TV^{spspspsp}VE^{spsp}RR^{spsp}O$_2^{spSP}$PK^{spsp}PT^{spSP}EE^{spsp}SET^{spsp}VT^{spsp}RR^{sp}
^{sp}IF^{spspspspsp}

I:E^{spsp}PL^{sp}LVE^{sp}LO^{sp}HO^{sp}MV^{sp}IP

Data frame:

d^{spspSsp}dddd^{sp}dd.dd^{sp}ddd^{sp}ddd^{sp}ddd^{sp}ddd^{sp}ddd^{spspspspsp}dddd^{sp}ddd^{sp}ddd^{sp}1:dd
d.d^{sp}ddd^{sp}d.d^{sp}dd^{sp}d d^{spspspsp}d^{spspsp}d<LF><CR>

(^{sp} = ASCII space character (32 decimal))

Measured Parameters

Heading	Format	Description	Units
S	d	sigh breath status	1=On, 0=Off
TV	dddd	tidal volume	mL, ?, -
VE	dd.dd	minute volume	L, ?, -
RR	ddd	respiratory rate	B/min, ?, -
O$_2$	ddd	oxygen concentration	% O$_2$
MAX	ddd	maximum pressure	cm H$_2$O, ?
PT	ddd	inspiratory plateau pressure	cm H$_2$O, ?,-
MIN	ddd	minimum pressure	cm H$_2$O, ?

Parameter Settings

Heading	Format	Description	Units
VT	dddd	tidal volume	mL
RR	ddd	respiratory rate	B/min
IF	ddd	inspiratory flow	L/min
I:E	1:ddd.d	inspiratory time: expiratory time ratio	–
PL	ddd	inspiratory pressure limit	cm H$_2$O
LVE	d.d	low minute volume alarm limit	L
LO	dd	low oxygen alarm limit	% O$_2$
HO	dd	high oxygen alarm limit	% O$_2$
MV	d	mechanical ventilation status	1=On, 0=Off
IP	d	inspiratory pause status	1=On, 0=Off

Heading will be printed once every 59 outputs.

If the measured Breath Rate exceeds 60 breaths/minute, data will be output every other breath in order to prevent partial loss of data.

Leading zeros are suppressed except for ones digit.

If in auto mode, output printed at end of each breath or every 10 seconds.

If in slave mode, output printed in response to each send all data command.

9-H—Using A Bain Circuit

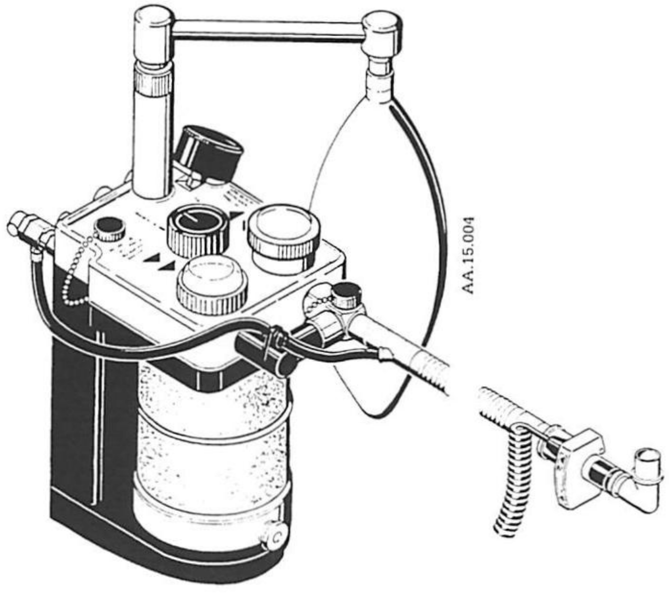
When you connect a Bain circuit and Bain circuit adapter to the Ohmeda 7810 Ventilator, you must place the volume sensor assembly in the proximal position, between the end of the Bain circuit and the patient connector to the ET (endotracheal) tube or mask. The volume sensor must be located in the proximal position to correctly measure the patient's exhaled volume in systems that include a Bain circuit.

With a Bain circuit, fresh gas from the gas machine flows through the breathing circuit for the entire respiratory cycle. If the volume sensor is located distally, the ventilator measures both the patient's exhaled volume and the fresh gas flow the Bain circuit adds to the exhaled volume. To avoid measuring this fresh gas flow, place the volume sensor proximally. When the volume sensor is in the proximal position, between the end of the Bain circuit and the patient connector to the ET tube or mask, the ventilator measures and displays the patient's exhaled volume.

If you are using a Bain circuit:

1. Locate the volume sensor assembly in the proximal position, between the end of the Bain circuit and the patient connector to the ET tube or mask.
2. Disable the ventilator's reverse flow alarm.

Figure 9-6
Correct placement of the volume sensor when used with a Bain circuit



9-I—Four Gas Anesthesia Systems

The four-gas anesthesia system is nearly identical to the standard three-gas model, with one exception—in the four-gas model, a pipeline Air supply is standard with an optional fourth gas cylinder.

The external differences between the two models are visible at—

- flowmeter modules
- pressure gauge panel
- gas supply labels

The four-gas model includes flow tubes, flow control valves and pressure gauges for Air and a fourth gas.

The internal differences between the three and four gas models occur in the pneumatic circuit. In the four-gas model, the gas supply assembly for Air and for the fourth gas is internally separated upstream of their flow control valves. The four-gas model has an Air DISS pipeline fitting and an Air pipeline supply pressure gauge. There is no provision for an Air cylinder, **so the only supply source for Air is the hospital pipeline.**

In addition, the gas supply assembly for the four-gas model includes a pin-indexed gas cylinder hanger yoke for the fourth gas and the appropriate cylinder supply pressure gauge. This is shown in the four gas pressure gauge window panel in figure 9-8.

Figure 9-7
Typical pressure gauge window, four-gas system

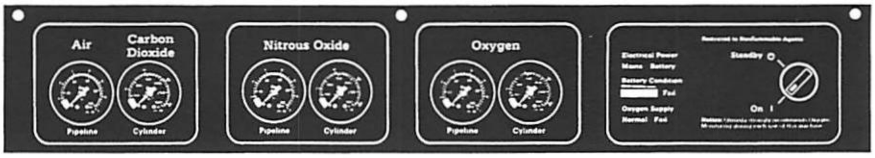

Air
Carbon Dioxide
Pipeline
Cylinder
Nitrous Oxide
Pipeline
Cylinder
Oxygen
Pipeline
Cylinder
Electrical Power
Mains Battery
Battery Condition
Fail
Oxygen Supply
Normal Fail
Standby
On
AA.12.158

Figure 9-8
Typical flowmeter modules for a four-gas system

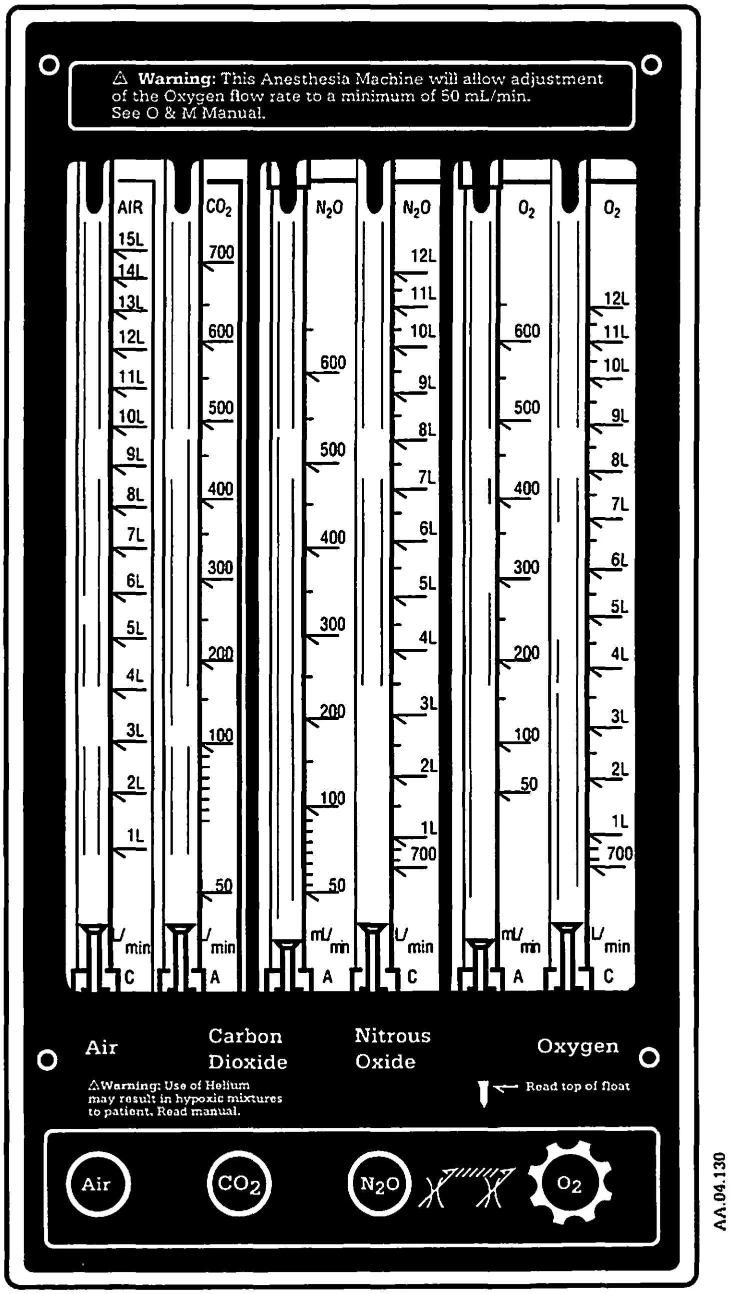
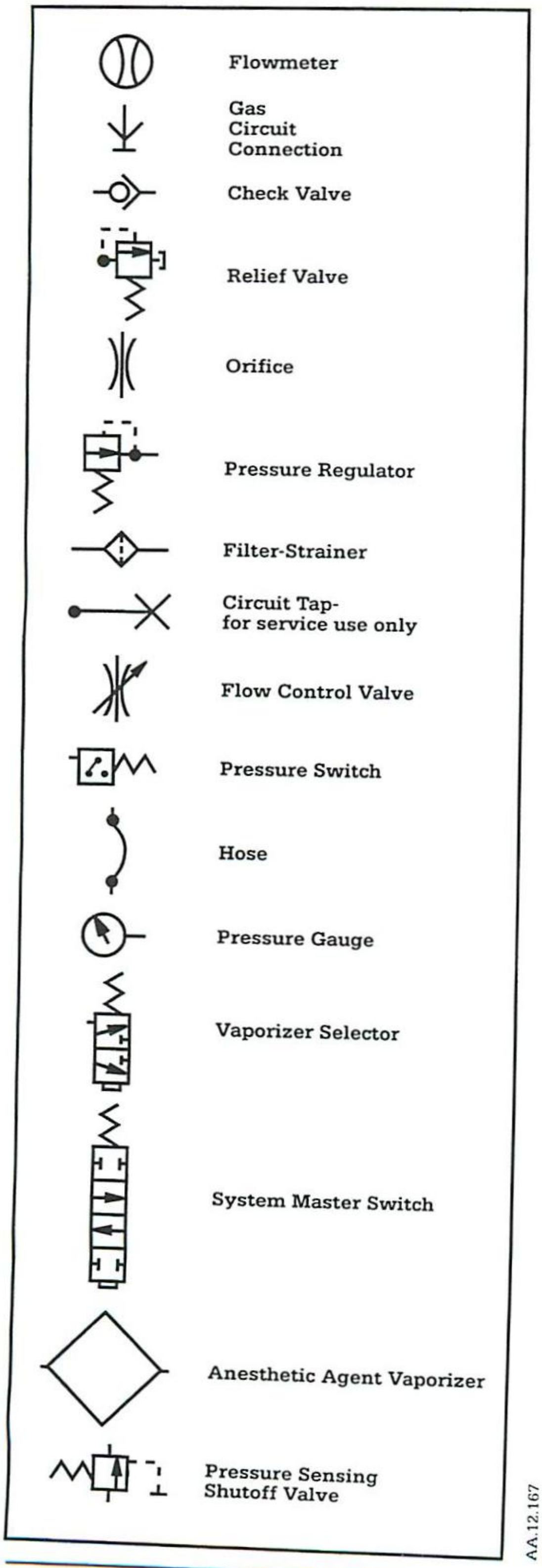
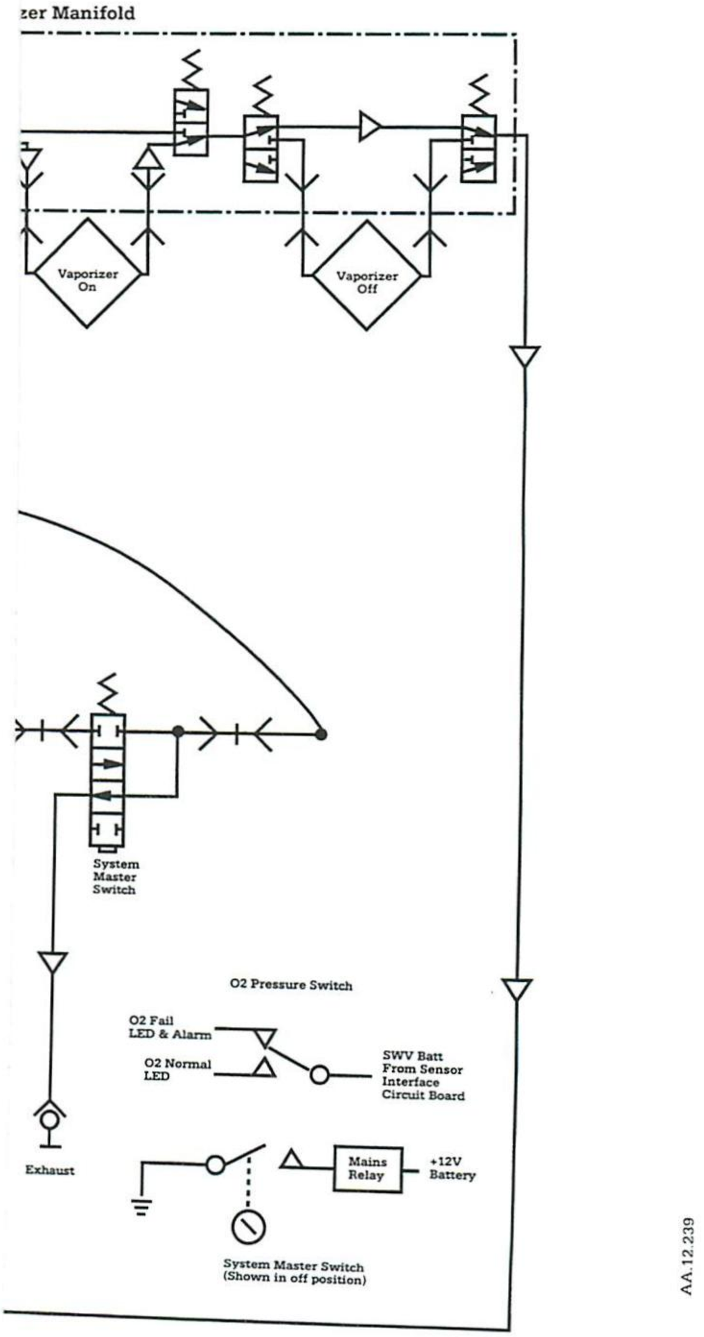
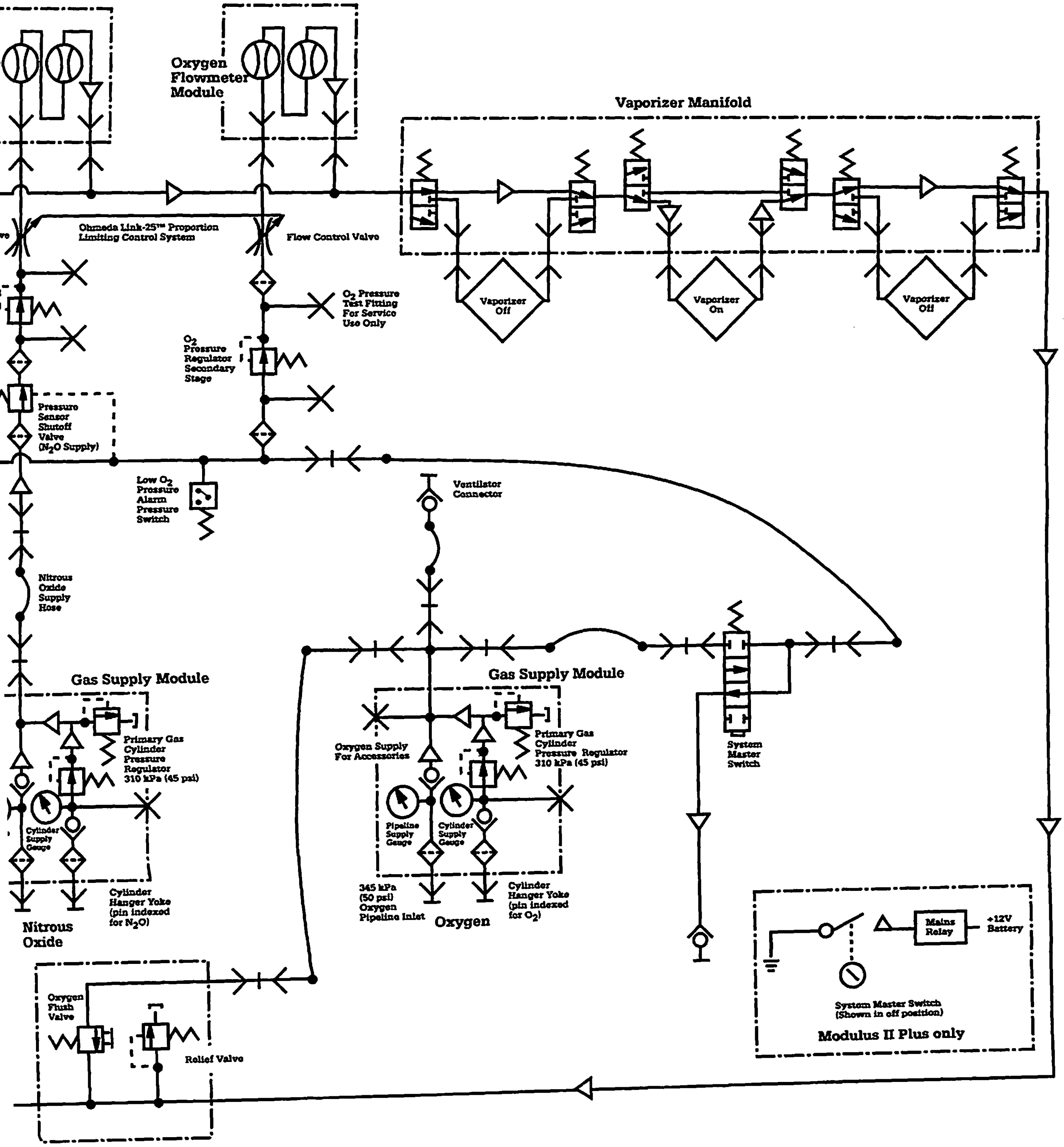

⚠ Warning: This Anesthesia Machine will allow adjustment of the Oxygen flow rate to a minimum of 50 mL/min. See O & M Manual.
AIR
15L
14L
13L
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
L/min
C
CO_2
700
600
500
400
300
200
100
50
L/min
A
N_2O
600
500
400
300
200
100
50
mL/min
A
N_2O
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
700
L/min
C
O_2
600
500
400
300
200
100
50
mL/min
A
O_2
12L
11L
10L
9L
8L
7L
6L
5L
4L
3L
2L
1L
700
L/min
C
Air
Carbon Dioxide
Nitrous Oxide
Oxygen
⚠Warning: Use of Helium may result in hypoxic mixtures to patient. Read manual.
Read top of float
Air
CO_2
N_2O
O_2
AA.04.130

Figure 9-9
Pneumatic schematic diagram of the typical three-gas anesthesia machine.


Flowmeter
Gas Circuit Connection
Check Valve
Relief Valve
Orifice
Pressure Regulator
Filter-Strainer
Circuit Tap- for service use only
Flow Control Valve
Pressure Switch
Hose
Pressure Gauge
Vaporizer Selector
System Master Switch
Anesthetic Agent Vaporizer
Pressure Sensing Shutoff Valve
AA.12.167


zer Manifold
Vaporizer On
Vaporizer Off
System Master Switch
O2 Pressure Switch
O2 Fail LED & Alarm
O2 Normal LED
SWV Batt From Sensor Interface Circuit Board
Exhaust
Mains Relay
+12V Battery
System Master Switch (Shown in off position)
AA.12.239


Oxygen Flowmeter Module
Vaporizer Manifold
Ohmeda Link-25™ Proportion Limiting Control System
Flow Control Valve
O$_2$ Pressure Test Fitting For Service Use Only
Vaporizer Off
Vaporizer On
Vaporizer Off
O$_2$ Pressure Regulator Secondary Stage
Pressure Sensor Shutoff Valve (N$_2$O Supply)
Low O$_2$ Pressure Alarm Pressure Switch
Ventilator Connector
Nitrous Oxide Supply Hose
Gas Supply Module
Primary Gas Cylinder Pressure Regulator 310 kPa (45 psi)
Cylinder Supply Gauge
Cylinder Hanger Yoke (pin indexed for N$_2$O)
Nitrous Oxide
Gas Supply Module
Oxygen Supply For Accessories
Primary Gas Cylinder Pressure Regulator 310 kPa (45 psi)
Pipeline Supply Gauge
Cylinder Supply Gauge
345 kPa (50 psi) Oxygen Pipeline Inlet
Oxygen
Cylinder Hanger Yoke (pin indexed for O$_2$)
System Master Switch
Mains Relay
+12V Battery
System Master Switch (Shown in off position)
Modulus II Plus only
Oxygen Flush Valve
Relief Valve

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This product is sold by Ohmeda under the warranties set forth in the following paragraphs. Such warranties are extended only with respect to the purchase of this Product directly from Ohmeda or Ohmeda's Authorized Dealers as new merchandise and are extended to the first Buyer thereof, other than for purpose of resale.

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